Table 4-3. Characteristics of Key Respondent Groups

Characteristic	User Mean	User Standard devi- ● tion	User N	Nonuser Mean	Nonuser Standard devi- ation	Nonuser N	Zero Meen	Zero Standard devi- ● tkm	Zero N	Nonzero Mean	Nonzero Stenderd devi- ● tion	Nonzero N	Protest Bids[a] Mean	Protest Bids[a] Standard devi- ● tion	Protest Bids[a] N	Total Mean	Total Standard devi- ation	Total N	Five count y rag ion in 1660	Sample
1=yes, 0=no for ownership or use of ● boat	0.23	0.43	64	0.12	0.32	207	0.11	0.32	106	0.18	0.35	193	0.15	0.37	56	0.16	0.36	301		
1=yes, 0=no for participation in ● ny outdoor recreation in the last year	0.65	0.23	64	0.36	0.49	207	0.35	0.49	106	0.66	0.45	193	0.50	0.50	56	0.56	0.50	301		
Numerical rating of the Monogahela River: 0=lowest, 10-highest	3.87	1.98	89	3.77	2.01	132	3.51	1.76	61	3.52	2.07	180	3.63	1.68	3S	3.81	1.68	221		
1=yes, 0-no If rating la for ● particular site	0.34	0.48	54	0.06	0.27	207	0.07	0.28	108	0.21	0.41	193	0.10	0.31	56	0.16	0.37	301		
Length of residence	6.83	0.%	94	6.50	1.02	207	6.62	0.65	106	6.80	1.02	153	6.74	1.18	56	6.61	1.00	301		
Years of education	13.06	1.96	66	12.61	2.12	177	12.36	2.20	66	12.93	1.65	177	12.77	1.73	47	12.75	2.07	253	10.96[b]	12.75
Rue (1 If white)	0.56	0.32	64	0.91	0.25	206	0.64	0.23	107	0.88	0.33	153	0.93	0.28	57	0.90	0.30	300	.92	.30
come	20,833	13,462	87	18,867	13,022	173	17,577	11,500	67	20,534	13,876	173	19,665	11,464	46	19, 536	13,164	260	19,687[b]	19,536
Age	36.93	16.20	94	51.67	17.85	207	54.55	16.91	106	44.06	10.07	193	52.80	17.27	56	47.82	18.34	301	45.6	47.6
sex (1 if male)	.31	.46	64	0.38	0.49	207	0.35	0.46	106	0.37	0.46	193	0.44	0.50	58	0.36	0.48	301	.47	.36

SOURCE: U.S. Bureau of the Census. 1980 Census of the Population and Mousing. Washington, D.C. 1SS2.

● PXt bias are zero bids for reasons other than "all they could afford" or 'that la what it Is worth. "

[b]Statewide ● tatlatlca.

To develop a reasonably clear snapshot of the respondent group important for the analysis of survey results, no adjustments for outliers are included in the profile information. The first two columns of Table 4-3 compare users and nonusers of the Monongahela River. The users are broadly defined based on all respondents who reported a user value or visited one of the 13 Monongahela River sites. This broader definition of user can be contrasted with a narrow definition that includes only those respondents who visited a site. The broader definition is used throughout this report because it allows for the inclusion of some users who may have been prevented from visiting a Monongahela site within the 12 months between November 1981 and November 1982 for medical or other personal reasons but still had some user value for the services of the Monongahela. Tests indicated that the differences between the user definitions were insignificant. This broad definition explains why a few Monongahela River users had not participated in an outdoor recreation activity in the second row of Table 4-3.

Results of t-tests for differences between the means of users and nonusers (shown in Appendix C) highlight some important distinctions that continue throughout the survey results. Users of the Monongahela River are younger, are more likely to own a boat, and are more likely to have rated a particular Monongahela River site than their nonuser counterparts. The water quality ratings place the Monongahela above beatable, but a full point below fishable, on the Water Quality Ladder (see Figure 4-5); however, the ratings are not different between the two groups. There are no differences in education, income, race, sex, or length of residence between users and nonusers. *

For these two groups t-tests for differences in means between zero and nonzero bidders and a logit analysis comprise the analysis. Based on these results, nonzero bidders were on average younger than zero bidders, earned higher annual family incomes, were more likely to have rated the Monongahela at a particular site, and have participated in outdoor recreation during the last year. These results are consistent with the findings of Mitchell and Carson [1981]. In addition,no significant differences existed between the groups in terms of sex, education, water quality rating for the river, boat ownership, and length of residence in the area. The protest bidders who rejected some aspect of the contingent valuation approach had higher incomes and were more likely to have participated in outdoor recreation in the last year than were those with valid zero bids.

The questionnaire design also provided the respondent's reason for giving a zero bid. These responses are shown in Table 4-4 for the four elicitation methods. The direct question method without the payment card yielded most of the respondents who could not place a dollar value on water quality,

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*The percentage of woman respondents (64 percent) in the sample is somewhat higher than in other studies--a somewhat surprising result since the random procedure used to select the respondents should have given a more even distribution. The respondent was asked to respond for the household, which should reduce any potential bias.

Table 4-4. Reasons for Zero Bids by Elicitation Method

Reason for zero bid	Payment card	Direct question	$25 iterative bidding	$125 iterative bidding	Total
Not enough information	1	1	0	2	4
Cannot place dollar value	4	9	2	0	15
Objected to way question was presented	0	0	1	0	1
That is what it is worth	12	10	7	11	40
Other	1	5	5	5	16
All they could afford	1	3	1	5	10
Government waste or misuse of tax dollars	2	0	2	1	5
Industry pollutes so let them clean it up	3	2	3	0	8
Taxes are too high already	2	3	1	2	8
Desire no increase in taxes for something that does not affect respondent	1	0	0	0	1
Total	27	33	22	26	108

which roughly indicates the value of either the payment card or the starting value in the bidding process. Approximately 40 percent of the respondents bid zero because that is what they felt the water quality is worth. Some evidence of the consistency in the response is indicated by the 10 respondents who bid zero because that is all they could afford. These respondents tended to be elderly persons living on limited incomes.

Table 4-5 shows the attitudinal information broken down for user, nonuser, and zero bids. These responses on the importance of water quality were elicited during the discussion of the value card (see Figure 4-6) and prior to the elicitation of the willingness-to-pay amounts. These responses are very consistent with the earlier characteristics of the groups. Users and nonzero bidders were much more likely to have given very or somewhat important responses to the questions than were nonusers and zero bidders.

Table 4-6 completes the profiles of the three groups by highlighting the respondents' willingness to identify themselves by certain labels. Several interesting features are apparent from these attitudinal responses. The users and nonzero bidders were much more likely to identify themselves as outdoors persons than were nonusers and zero bidders. However, the differences between the groups is much smaller for the environmentalist label, with 26 per-

Table 4-5. Degree of Importance of Water Quality by Key Respondent Groups

Degree of importance of water quality	User		Nonuser		Zero bids		Nonzero bids		Protest bids[a]		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
For own recreation												
Very important	47	50.0	48	23.3	20	18.5	75	39.1	16	27.6	95	31.7
Somewhat important	28	29.7	36	17.5	14	13.0	50	26.0	9	15.5	64	21.3
Neither important nor unimportant	4	4.3	33	16.0	21	19.4	16	18.3	14	24.1	37	12.3
Not very important	10	10.6	46	22.3	25	23.1	31	16.1	11	19.0	56	18.7
Not important at all	5	5.3	43	20.9	28	25.9	20	10.4	8	13.8	48	16.0
Total	94		206		108		192		58		300	
For possible future use												
Very important	49	52.1	70	33.8	27	25.0	92	47.7	16	27.6	119	39.5
Somewhat important	34	36.2	53	25.6	21	19.4	66	34.2	14	24.1	87	28.9
Neither important nor unimportant	5	5.3	26	12.6	18	16.7	13	6.7	13	22.4	31	10.3
Not very important	3	3.2	33	15.9	23	21.3	13	6.7	9	15.5	36	12.0
Not important at all	3	3.2	25	12.1	19	17.6	9	4.7	6	10.3	28	9.3
Total	93		207		108		193		58		301	
Even if never use river												
Very important	49	52.7	74	35.7	27	25.0	96	50.0	19	32.8	123	41.0
Somewhat important	29	31.2	70	33.8	33	30.6	66	34.4	18	31.0	99	33.0
Neither important nor unimportant	7	7.5	21	10.1	15	13.9	13	6.8	9	15.5	28	9.3
Not very important	6	6.5	27	13.0	22	20.4	11	5.7	9	15.5	33	11.0
Not important at all	2	2.2	15	7.2	11	10.2	6	3.1	3	5.2	17	5.7
Total	93		207		108		192		58		300	

[a]Protest bids are zero bids for reasons other than “all they could afford” or “that is what it is worth. ”

Table 4-6. Respondent Attitudes About Self by Key Respondent Groups

Attitude	User		Nonuser		Zero bids		Nonzero bids		Protest bids[a]		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
An outdoors person												
A lot	42	44.7	50	24.2	29	26.9	63	32.6	20	34.5	92	30.6
Somewhat	24	25.5	56	27,1	23	21.3	57	29.5	12	21.0	80	26.6
A little	19	20.2	38	18.4	21	19.4	36	18.7	9	15.5	57	18.9
Not at all	9	9.6	63	30.4	35	32.4	37	19.2	17	29.3	72	23.9
No opinion	0	0	0	0	0	0	0	0	0	0	0	0
Total	94		207		108		193		58		301	
An environmentalist												
A lot	26	27.7	38	18.4	28	26.2	36	18.7	20	35.1	64	21.3
Somewhat	27	28.7	56	27.2	14	13.1	69	35.8	10	17.5	83	27.7
A little	30	31.9	51	24.8	24	22.4	57	29.5	10	17.5	81	27.0
Not at all	11	11.7	59	28.6	39	36.4	31	16.1	15	26.3	70	23.3
No opinion	0	0 “	2	1.0	2	1.9	0	0	2	3.5	2	0.7
Total	94		206		107		193		57		300	
Against nuclear power electric plants												
A lot	27	28.7	45	21.8	26	24.1	46	24.0	15	25.9	72	24.0
Somewhat	12	12.8	19	19.2	13	12.0	18	19.4	9	15.5	31	10.3
A little	15	16.0	23	11.2	8	7.4	30	15.6	3	5.2	38	12.7
Not at all	31	33.0	79	38.4	37	34.3	73	38.0	20	34.5	110	36.7
No opinion	9	9.6	40	19.4	24	22.2	25	13.0	11	19.0	49	16.3
Total	94		206		108		192		58		300	
Concerned about water pollution												
A lot	45	48.4	87	42.0	41	38.0	91	47.4	28	48.3	132	44.0
Somewhat	29	31.2	71	34.3	31	28.7	69	35.9	17	29.3	100	33.3
A little	15	16.1	29	14.0	18	16.7	26	13.5	8	13.8	44	14.7
Not at all	4	4.3	17	8.2	16	14.8	5	2.6	5	8.6	21	7.0
No opinion	0	0	3	1.4	2	1.8	1	0.5	0	0	3	1.0
Total	93		207		108		192		58		300	
Willing to pay the cost required to control water pollution												
A lot	19	20.4	31	15.0	8	7.5	42	21.9	6	10.5	50	16.7
Somewhat	42	45.2	59	28.6	18	16.8	83	43.2	10	17.5	101	33.8
A little	21	22.6	50	24.3	15	14.0	56	29.2	9	15.8	71	23.7
Not at all	10	10.8	58	28.2	58	54.2	10	5.2	28	49.1	68	22.7
No opinion	1	1.1	8	3.9	8	7.5	1	0.5	4	7.0	9	3.0
Total	93		206		107		192				299	

[a]Protest bids are zero bids for reasons other than “all they could afford” or ‘(that is what it is worth. ”

cent of the zero bidders indicating the closest identity with the label. This is even more evident when only the protest zero bids are examined. Thirty-five percent gave the strongest response, which is consistent with the frequency responses shown in Table 4-4 for the reasons why people bid zero. The most dramatic differences between respondents are evident in the willingness to pay the cost required to control water pollution. Only 24 percent of the zero bidders were willing to identify with this descriptive statement. This consistency across different attitude responses suggests that the respondents correctly perceived the contingent valuation experiment and gave careful responses that would not have been given if hypothetical bias were present. It is also suggestive of the importance of attitudinal questions in contingent valuation studies both for analysis purposes and as consistency checks.

Table 4-7. Logit Estimation of Zero Bids[a]

Independent variable	Coefficient	t-ratio[b]	Derivative of the probability evaluated at the mean
Constant	-0.435	-0.251	
Sex	-0.522	-0.924	-0.042
Age	0.036	2.703[c]	0.003
Education	-0.108	-0.867	-0.009
Income	6.9×10^{-9}	0.326	0.59×10^{-6}
Version B	-0.319	-0.506	-0.026
Version C	-1.728	-2.407[c]	-0.113
Version D	-0.665	-1.099	-0.050
Willing to pay cost of water pollution (1 if very much or somewhat)	-1.622	-3.185[c]	-0.169
Interviewer #1	-0.625	-0.627	-0.044
Interviewer #2	1.095	1.318	0.128
Interviewer #3	-0.683	-0.807	-0.050
Interviewer #5	-1.158	-0.913	-0.072
Interviewer #7	-1.519	-1.175	-0.082
Interviewer #8	0.192	0.215	0.017
interviewer #9	1.099	0.843	0.141

Note: Log of likelihood function = 65.511. Estimated marginal probabilities for mean value of dependent variables: Probability = 1, 0.095; probability = 0, 0.905.

[a]The dependent variable is equal to 1 if the individual bid zero dollars and zero otherwise. All protest bids were eliminated.

[b]The t-ratio is the ratio of the estimated parameter to the estimated standard error. Given the assumptions of the estimates are maintained, the maximum likelihood, logit parameter estimates are asymptotically normal. We have used a t-distribution in judging the significance of these parameter estimates.

[c]Significant at the 5-percent level.

Additional insight into zero bidders issues can be obtained from a logit analysis of valid zero bids (see Amemiya [1981]). To perform this analysis for the Monongahela study, the dependent variable was set equal to 1 if a nonprotest zero bid was given and equal to zero if a positive bid was given. Consequently/protest bids were eliminated from the analysis. For consistency, the explanatory variables used are the same as in the option price regression (as discussed in Section 4.5). The binary variable to denote Monogahela users and several interviewer dummies were eliminated due to a lack of variation.

The results of the logit analysis of zero bidders are shown in Table 4-7. This model requires a cautious interpretation of the estimated coefficients. In the logit procedure,the expected change in the probability of bidding zero is derived from the estimated equation where the probability of bidding zero depends on the value of the independent variables.

The results were encouraging, with no evidence of interviewers significantly affectingthe odds of bidding zero. The performance of other variables is consistent with previous results and a priori reasoning. Increases in age significantly affected the likelihood of bidding zero. Each year's increase, evaluated at the mean, is expected to change the probability of bidding zero by 0.003. The results also indicate a relationship between zero bids and questionnaire version. When the respondent was presented with the $25 bidding game rather than the payment card, the probability of bidding zero decreased by 0.113. Also, the attitude toward cost was consistent, because those respondents who stated a willingness to pay a portion of cleanup cost had a lower probability of bidding zero.

The logit model was also used to explain why individuals protested the option price question. As shown in Appendix C, the results are very weak, with only the attitude toward cost variable significant and all other analysis variables insignificant.

4.5 OPTION PRICE RESULTS

The central element in a contingent valuation study is the valuation responses revealed in the hypothetical market situation. Much of the analysis in the early contingent valuation experiments focused on the fitting of a bid function to the willingness-to-pay bids. In this section, a linear approximation is used in a regression analysis to fit the bid function. However, the basic emphasis of the regression analysis is to organize the information presented and not to estimate the bid function. *

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*The willingness-to-pay data contain no negative bids which implies that they are truncated at zero. This can lead to biased parameter estimates with regression analysis, depending upon the distribution of bids. Since the sample excludes protest bidders, all responses should fall in the positive domain. Negative responses would be inconsistent with the group being described by the model. The difficulties posed by truncation could be handled in a variety of ways including: transforming the dependent variable (i.e. , using the log

Specifically, this section summarizes the analytical basis of the option price and user amounts, the statistical procedures employed to analyze these estimates, the comparison of estimates between elicitation methods, and the results on starting point and interviewer bias. In addition, it also compares results with those from previous studies.

The amounts provided by the respondents represent their option prices rather than user willingness to pay, as measured in many previous contingent valuation studies. That is, the option price includes both the expected consumer surplus that respondents anticipate from future use of the site's services as well as a premium--the option value--that they are willing to pay to obtain these site services should they decide to use them. The premium can be attributed to uncertainty either in the respondents' future demand for the site and/or uncertainty in the supply of the site's services at given water quality levels. Chapter 5 explores these issues in more detail, but it is important to understand this distinction to correctly interpret the results.

As discussed in Chapter 2, the option price amounts are based on the Hicksian surplus measures, with the equivalent surplus measure used for the loss of the recreation services of the Monongahela River (Level D to Level E) and the compensating surplus measures used in measuring the option price for the improvements to fishable and swimmable water. The use of these measures corresponds to the existing property rights for the overall level of Monongahela recreation services, with the river currently supporting boating activities. It is important to note that several sections of the Monongahela have considerably higher water quality and are capable of supporting sport fishing due to the influence of tributaries. However, the boatable designation is a reasonable description of the overall water quality level.

Determining the treatment of outlying responses is an important step in a contingent valuation study. Randall, Hoehn, and Tolley [1981] suggest that, once the outliers are determined and removed, the contingent valuation method will provide a "core" of responses useful for analysis. In general, previous efforts have used subjective judgment in making this determination, with little or no discussion provided. For example, Rowe, d'Arge, and Brookshire [1980] follow the procedure mentioned in Randall, Ives, and Eastman [1974] of eliminating bids greater than 10 standard deviations from the mean. In neither case is much discussion provided on the judgments made in selecting this procedure. While the role of judgment will almost always loom large in these decisions, it is difficult to evaluate and transfer the methods used to evaluate the contingent valuation results unless a more systematic basis for the judgment is detailed.

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of the bids, if the zero bidders were dropped) and using an alternative estimator. For the purposes of the present analysis, these models are intended to be used only as a basis for judging the factors likely to influence bids and not necessarily to estimate the magnitude of their impact. Past evidence on the bias of ordinary least squares in presence of truncation effects indicates that it did not greatly affect these judgmental evaluations of specific variables.

Our approach relies on more formal use of statistical indexes of the influence of particular observations on a model's etimated parameters. Belsley, Kuh, and Welsch [1980] suggest a number of statistical' procedures that can be used in prescreening data for outliers. The Monongahela study used a procedure that follows their discussion to identify outlier candidates. The Belsley-Kuh-Welsch statistic (DFBETA) measures the effect of each individual observation on each of the estimated coefficients in a regression model. It is estimated by Equation (4.1):

$$\text{DFBETA} \equiv b - b(i) = \frac{(X^T X)^{-1} x_i^T e_i}{1-h_i} \tag{4.1}$$

where

b = the estimated coefficient with all observations included

$b(i)$ = the estimated coefficient with one less observation

$h_i = x_i (X^T X)^{-1} x_i^T$

e_i = the ordinary least-squares residuals.

This statistic is not a formal statistical test. It is merely an index of the extent of influence of particular observations. It implicitly assumes that option prices can be related to economic characteristics. In this application, the statistics presented in the first column of Table 4-8 are expressed as percentage changes in the income coefficient of the final regression model discussed later in this chapter. The effect of income was selected because this variable is the only variable we know, based on economic theory, that should influence option price bids. Moreover, the relationship between option price and user value can be expected to be influenced by the role of income in an individual's indirect utility function. These changes represent approximations of elasticities described in Belsley, Kuh, and Welsch [1980].

Rather than employ one of the arbitrary statistical criteria suggested in Belsley, Kuh, and Welsch, the procedure was supplemented in this study with a judgment that (±) 30 percent was the cutoff point for outliers. An element of judgment is also required in selecting the regression model from which the Belsley-Kuh-Welsch statistic is calculated. After comparing models, the judgment was made to select the general model presented later in Table 4-11. However, in comparing the results between the models, the 16 outliers determined by the same cutoff point for another regression model (see Appendix G) were all included in the 32 outliers profiled in Table 4-8.

The results in Table 4-8 are striking in terms of the differences from the Randall, Ives; and Eastman [1974] criteria. Many of the outliers are small or zero bids that would have been retained in their procedure. In addition, the consistency in the characterization of the outliers is informative. For the respondents classified as outliers, 63 percent earned annual incomes of $2,500

Table 4-8. Profile of Outliers

Belsley-Kuh-Welsch statistic	Version	Option price: avoid loss of site (D to E) ($/yr)	Option price: improve water quality to swimmable ($/yr)	Income $/yr	Age (yr)	Sex	Education (yr)	User of Monongahela site	Boat ownership
-233.12	$125 bidding game	$125	$260	2,500	25	Male	12	No	No
-155.99	$125 bidding game	$125	200	2,500	20	Female	12	Yes	No
-100.04	direct question	$200	200	7,500	67	Male	12	No	No
-79.83	$125 bidding game	500	500	22,500	39	Male	14	No	Yes
-66.19	$125 bidding game	$125	220	7,500	43	Female	10	Yes	No
-63.25	$25 bidding game	25	5	2,500	70	Female	10	No	No
-62.95	payment card	450	200	17,500	37	Female	12	Yes	No
-56.70	$25 bidding game	60	85	2,500	23	Female	12	No	No
-54.98	direct question	0	10	2,500	82	Female	10	No	No
-49.68	payment card	50	250	7,500	40	Female	14	Yes	No
-44.62	$125 bidding game	155	250	12,500	57	Female	12	No	No
-43.80	$25 bidding game	5	5	2,500	69	Female	10	No	No
-43.16	$125 bidding game	155	250	12,500	44	Female	10	No	No
-37.34	$25 bidding game	5	5	2,500	62	Female	10	No	No
-36.46	$25 bidding game	25	0	2,500	46	Female	10	No	No
-36.03	$25 bidding game	0	0	2,500	76	Female	16	No	No
-31.40	direct question	200	300	27,500	21	Female	12	Yes	No
-30.43	$125 bidding game	200	285	22,500	66	Female	12	Yes	No
31.24	direct question	5	3	7,500	34	Male	12	No	No
33.98	$125 bidding game	0	0	12,500	38	Female	12	No	No
35.39	$125 bidding game	0	0	2,500	78	Female	0	No	No
37.77	payment card	75	10	2,500	59	Female	12	Yes	No
41.78	payment card	25	10	2,500	72	Female	12	No	No
47.15	$125 bidding game	5	130	2,500	61	Female	12	Yes	No
52.23	$125 bidding game	0	30	7,500	50	Female	12	Yes	No
52.86	payment card	0	0	2,500	43	Female	10	No	No
58.18	$125 bidding game	0	0	2,500	79	Female	10	No	No
65.70	$125 bidding game	0	10	2,500	66	Female	12	No	No
69.1S	direct question	10	20	2,500	33	Female	12	Yes	No
79.58	$125 bidding game	55	0	2,500	71	Female	10	No	No
82,52	payment card	0	0	2,500	53	Female	12	No	No
112.04	payment card	0	25	2,500	26	Female	12	Yes	Yes

a year or less and 78 percent earned less than $7,500 a year. Female respondents comprised of 80 percent of the outliers, while only 4 respondents had more than a high school degree. The last element of interest is that 14 of the 32 outliers had received the $125 starting point bidding game--twice as many as the next version (the payment card). This last feature confounds the interpretation of starting point bias presented later in this and the following chapter.

In summary, the Belsley-Kuh-Welsch [1980] procedure is a systematic approach for identifying outlying bids within contingent valuation studies. It does not replace the need for judgment but gives a basis for making the judgments.

The results presented in this chapter are all based on two edits of the 301 completed survey questionnaires. The first edit removed the protest bids from the calculation of means and the regressions. Protest zeros were respondents who bid zero for reasons other than "that is all they could afford" or "that is what it was worth." This removal is consistent with practices of Randall, Ives, and Eastman [1974] and Rowe, d'Arge, and Brookshire [1980] .

The second edit removed the outliers following the Belsley-Kuh-Welsch [1980] procedure. Appendix C presents the estimated means for both the full sample and the sample with only the protest bids excluded. Calculated t-statistics revealed no statistically significant differences between the means estimated from the full sample and those estimated with the protest bids excluded. The effects of omitting the outlier observations are discussed at the appropriate Points in this and in the following chapter.

The salient questions to be answered from the survey results center on the comparison of the alternative methods used to elicit the option price amounts, while the plausibility of the results is substantiated by testing for potential biases in the responses. Table 4-9 presents the estimated means grouped by questionnaire version, with distinctions made between users and nonusers. The mean values are provided for the loss of the recreation services of the site (avoiding a decrease from Level D to Level E on the water quality ladder in Figure 4-5), for an improvement in water quality from boatable to fishable (Level D to Level C), and for an improvement in water quality from fishable to swimmable (Level C to Level B). Combined option prices are presented for the improvements in the level of water quality and for the improvements plus the loss of the services of the site.

One inference that can be drawn from Table 4-9 is that the option prices are sizable for the Monongahela River but are of the same order of magnitude regardless of the method used to elicit the amount. Option price amounts combined for all levels range from a mean of $54 per year for the bidding game with a $25 starting bid to $118 for the bidding game with a $125 starting bid. Mean bids for the combined amounts for the payment card and direct question equaled $94 and $56, respective y. The range of mean option price amounts is even narrower when only the bids for improvements are considered, varying from $25 per year to $60 per year for the two bidding games.

Table 4-9. Estimated Option Price for Changes in Water Quality: Effects of 1 nstrument and Type of Respondent-- Protest Bids and Outliers Excluded

Change in water quality	User			Nonuser			Combined		
	$\bar{X}$	s	n	$\bar{X}$	s	n	$\bar{X}$	s	n
1. Iterative bidding framework--starting point = $25 (Version C)									
D to E avoid	27.4	16.7	19	29.7	35.7	39	29.0	30.6	58
D to C	18.9	16.3	19	14.5	15.2	39	15.9	15.5	58
C to B	11.8	14.5	19	7.2	11.6	39	8.7	12.7	58
D to B[a]	32.1	27.1	19	21.7	24.0	39	25.1	25.3	58
Combined: all levels	59.5	38.1	19	51.4	53.1	39	54.1	48.5	58
2. iterative bidding framework--starting point = $125 (Version D)									
D to E (avoid)	94.7	66.0	16	38.8	51.3	32	57.4	62.0	48
D to C	58.1	51.9	16	26.3	45.4	32	36.9	49.5	48
C to B	33.1	48.4	16	11.6	33.1	32	18.8	39.7	48
D to B	99.7	87.9	16	40.5	69.0	32	60.2	80.0	48
Combined: all levels	194.4	136.5	16	79.2	102.5	32	117.6	126.0	48
3. Direct question framework (Version B)									
D to E (avoid)	45.3	65.2	17	14.2	27.1	34	24.5	45.4	51
D to C	31.3	44.2	17	10.8	21.6	34	17.6	32.1	51
C to B	20.2	35.5	17	8.5	21.9	34	12.4	27.4	51
D to B	52.9	72.5	17	20.3	41.4	34	31.2	55.2	51
Combined: all levels	98.2	103.5	17	34.5	66.4	34	55.7	85.2	51
4. Direct question framework: payment card (Version A)									
D to E (avoid)	46.8	42.2	17	53.0	76.3	37	51.0	67.1	54
D to C	45.3	71.4	17	21.9	33.8	37	29.3	49.3	54
C to B	22.9	48.7	17	7.7	20.0	37	12.5	32.2	54
D to B	71.2	117.7	17	29.9	47.5	37	42.9	78.1	54
Combined: all levels	117.9	117.0	17	82.8	104.7	37	93.9	108.9	54

[a]D to B are the combined amounts for improvements only.

The results of the test for differences in means between methods for both users and nonusers are shown in Table 4-10. These results show that the differences do arise between the means in the bidding games, suggesting there may be a bias attributable to the difference in the starting points. The combined and user means are statistically different at the 5-percent level of significance for users and for the combined groups. However, the evidence is not completely conclusive because the differences in nonuser means are not significant. In addition, the regression results shown in Table 4-11 do not conclusively show a starting point bias problem. The regression model estimated without the outliers shows no statistically significant difference between the iterative bidding games. If the outliers are not removed, the model suggests starting point bias, as indicated in Appendix C. Thus, in the regression

Table 4-10. Student t-Test Results for Option Price--
Protests Bids and Outliers Excluded

Means combined	User	Nonuser	Combined
payment card vs. direct question			
D to E	--	2.806	2.353
E to B	--	2.300	1.991
payment card vs. $25 iterative bidding			
D to E	--	--	2.263
D to C	--	--	1.954
E to B	2.061	--	2.530
payment card vs. $125 iterative bidding			
D to E	-2.499	--	--
Direct question vs. $25 iterative bidding			
D to E	--	-2.074	--
Direct question vs. $125 iterative bidding			
D to E	-2.161	-2.453	-3.020
D to C	--	--	-2.308
E to B	-2.289	-2.117	-2.8786
D to B	--	--	-2.109
$25 iterative bidding vs. $125 iterative bidding			
D to E	-4.294	--	-3.072
D to C	-3.119	--	-3.046
E to B	-4.131	--	-3.539
D to B	-3.183	--	-3.159

[a]Only cases with statistically significant differences in the means at the 0.05 significance level are reported.

analysis, differences attributable to starting point cannot be distinguished from the influence of the outlier observations.

Some additional insights into differences in the elicitation method can be developed from the results in Tables 4-10 and 4-11. The mean option price for users of the Monongahela is significantly higher when the bidding game with the $125 starting point is used to elicit option price compared to either direct question technique. The differences are present for the aggregate option price and for the loss of site services, but no differences are detected for the incremental improvements to fishable and swimmable water quality levels.

The regression results from Table 4-11 are generally consistent with the means tests. Using the dummy variable technique to compare the payment card with the other three versions shows option price is significantly higher ‘or the payinent card than for the direct question and the $25 bidding game, while no differences exist between the payment card results and those for the

Table 4-11. Regression Results for Option Price Estimates-- Protest Bids and Outliers Excluded[a]

Independent variables	D to E (avoid)	D to C	C to B	Total, all levels	Total improvements only
	Water quality changes				
Intercept	-34.512	-29.307	-5.430	-56.653	-22.141
	(-0.973)	(-1.098)	(-0.257)	(-0.916)	(-.517)
Sex (1 if male)	8.451	-0.672	-1.657	6.484	1.967
	(0.916)	(-0.097)	(-0.302)	(0.403)	(-0.177)
Age	-0.292	0.290	-0.265	-0.854	-0.562
	(-1.094)	(-1.440)	(1.668)	(-1.834)	(1.743)
Education	5. 294	2.901	-5.27	8.066	2.773
	(2.071)[b]	(1.508)	(0.347)	(1.810)	(0.899)
Income	0.0006	0.0003	0.0003	0.0012	0.0006
	(1.652)	(1.151)	(1.260)		(1.278)
Direct question	-32.311	-14.372	-3.500	-50.734	-18.423
	(-2.771)[b]	(-1.638)	(0.505)	(-2.495)[b]	(-1.309)
Iterative bidding game ($25)	-20.623	-12.572	-5.657	-39.566	-18.943
	(1.852)	(-1.500)	(-.854)	(-2.037)[b]	(1.409)
Iterative bidding game ($125)	1.7522	6.639	0.739	31.089	13.568
	(1.421)	(0.716)	(0.101)	(1.446)	(0.912)
User (1 if user)	8.840	8.083	6.839[b]	26.026	17.187
	(0.919)	(1.117)	(1.86)	(1 .552)	(1,481)
Willing to pay cost of water pollution (1 if very much or somewhat)	17.001	21.960	10.023	51.326	34.326
	(1.788)	(3.068)[b]	(1.772)	(3.095)[b]	(2.990)[b]
Interviewer #1	14.211	7.090	11.334	26.509	12.298
	(0.750)	(0.497)	(1.006)	(0.802)	(0.538)
Interviewer #2	1.723	12.242	16.849	24.719	22.996
	(0.099)	(0.938)	(1.634)	(0.817)	(1.099)
Interviewer #3	-22.833	21.141	17.578	9.292	32.125
	(-1.344)	(1.653)	(1.740)	(0.314)	(1.567)
Interviewer #4	-28.125	3. 050	20-605	-12.334	15.791
	(-0.860)	(0.124)	(1 .059)	(-0.216)	(0.400)
Interviewer #5	6.932	4.996	2.191	11.435	4.503
	(0.404)	(0.387)	(0.215)	(0.382)	(0.217)
Interviewer #6	47.012	95.513	66.288	198.450	151.439
	(0.887)	(2.394)[b]	(2.102)[b]	(2.146)[b]	(2.366)[b]
Interviewer #7	27.670	2.470	4.130	39.645	11.975
	(1.425)	(0.169)	(0.357)	(1.170)	(0.511)
Interviewer #8	14.022	29.961	19.871	58.063	44.041
	(0.801)	(2.274)[b]	(1.808)	(1.902)	(2.08)[b]
Interviewer #9	17.874	39.586	-7.935	37.330	19.456
	(0.454)	(1.336)	(-0.339)	(0.544)	(0.409)
R^2	0.334	0.284	0.166	0.366	0.269
F	3.78	3.00	1.50	4.36	0.278
Degrees of freedom	136	136	136	136	136

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

[b]Significant at the 0.05 level.

bidding game with the $125 starting point. The differences are significant only for the loss of site services and for the combined option price. When other influences are held constant in the regression analysis, respondents who received the payment card expressed aggregate option prices approximately $40 to $50 higher than those expressed by respondents in the $25 starting point bidding game and the direct question. It is possible to conclude that there are-significant differences between methods but that all methods estimate option price at the same order of magnitude. The differences cannot be detected among the bids for improvements in water quality levels, possibly because the effects of the methods are limited to the initial amounts given. This may minimize the effect of the question format when incremental amounts are elicited. This conclusion should be viewed with some caution since the differences between methods could be difficult to detect simply because the number of bids for the improvements is too small to offset the variation in the amounts expressed. The consistency in the results from the various tests, however, is particularly encouraging as a plausibility check against the influence of hypothetical bias in the contingent valuation design.

An examination of the regression results for option price combined over all water quality levels reinforces the plausibility of the results. The coefficients of the socioeconomic variables all have the expected signs, and the coefficient for age, education level, and income are significant at either the 0.05 level or very close to it. The results indicate a strong role for respondent attitude toward paying the cost of water pollution. Persons who identified themselves as either very much or somewhat willing to pay for water pollution control were willing to spend $50 more per year than persons who were not willing to pay the cost, with all other things held constant. This consistency of attitudes, combined with the performance of the socioeconomic variables and the ability of the code to explain almost 37 Percent of the variation in option price, builds a strong case against the Influence of hypothetical bias in the contingent valuation design.

The regression results in Table 4-11 also shed some light on the question of a bias in the willingness to pay that could be attributable to differences in interviewers. Using the dummy variable technique,the results indicate that the influence of interviewer bias is limited. Only for two interviewers are the coefficients statistically significant at the 0.05 level for some levels of water quality. One of the cases involved an interviewer who conducted only two interviews before being removed from the interviewing team. This interviewer did not take part in the training session and also conducted interviews only in the Latrobe area, which is a considerable distance from the Monongahela River. The second interviewer also conducted interviews in the Latrobe area and in one area very close to the river. These cases may simply reflect the model's inability to differentiate between an interviewer effect and some omitted variables. Thus, the effect of the interviewer is quite small and reinforces the importance of the training sessions that were conducted in Pittsburgh prior to the survey. *

Table 4-12 presents the results of student t-tests for differences in means between users of the Monongahela River and nonusers broken down by the technique used to elicit option price. The results show that users who received either the direct question or the $125 starting point bidding game expressed bids that were higher than those of nonusers. There were no statistically significant differences in means for either the payment card or the $25 starting point. This suggests that users have somewhat higher option prices,

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*To conclusively design a test for interviewer bias would require that interviewers be randomly assigned to different areas in the survey. The practical issue is that this could have a significant impact on data collection costs because of interviewers having to cover a substantial part of the survey area. In the Monongahela survey, interviewers were assigned areas based on the lowest travel costs to obtain the interview.

Table 4-12. Student t-Test Results for Option Price--
Protest Bids and Outliers Excluded

Means compared	User vs. nonuser	Means compared	User vs. nonuser
Payment card (A)		$25 iterative bidding (C)	
D to E	-0.313	D to E	-0.275
D to C	1.645	D to C	1.026
C to B	1.322	C to B	1.322
D to B	1.103	D to B	0.591
E to B	1.847	E to B	1.488
Direct question (B)		$125 iterative bidding (D)	
D to E	2.414[a]	D to E	3.231[a]
D to C	2. 234[a]	D to C	2.186[a]
C to B	1.454	C to B	1.819
D to B	2. 669[a]	D to B	3. 279[a]
E to B	2. 049[a]	E to B	2. 555[a]

[a]Denotes significance at the 0.05 level.

but this difference is not pervasive. Thus, a survey of only the users of Monongahela River would have substantially underestimated the recreation and related benefits of water quality improvements. The full extent of these intrinsic benefits is developed in the following chapter.

4.6 USER VALUE RESULTS

Table 4-13 shows estimated user values, which resulted from respondents referring to the value card (see Figure 4-6) and breaking out the user value component of the option price. These values are comparable to those estimated in most of the previous contingent valuation efforts and are compared with the benefits estimated with the travel cost ‘method in Chapter 8.

User value means are presented for users only and the means calculated for all respondents. Tests to determine whether the user values are statistically different from zero, shown in Appendix C, indicated that the user values for the D to E levels and combined over all levels are statistically different from zero at the 0.05 level of significance. The user values for improvements in water quality are only different from zero for the $25 bidding game and not for any other methods. Additional tests for differences in user values between methods, also contained in Appendix C l showed that means from the $25 biddina games were statistically different (lower) than those estimated with the $125 bidding game, but only for Levels D to E and the user values for all combined water quality levels. The differences for the user

Table 4-13. Estimated User Values--Protest Bids and Outliers Excluded

	User only			Combined		
	$\bar{X}$	s	n	$\bar{X}$	s	n
Iterative bidding framework						
$25 starting point (C)						
D to E	6.59	12.59	19	2.16	7.73	58
D to C	4.21	7.68	19	1.38	4.76	58
C to B	5.00	7.99	19	1.64	5.08	58
D to B	10.53	14.43	19	3.45	9.52	58
Combined: all levels	17.11	25.13	19	5.60	16.28	58
Iterative bidding framework						
$125 starting point (D)						
D to E	36.25	58.98	16	12.08	37.52	48
D to C	20.31	42.67	16	6.77	25.98	48
C to B	20.00	42.82	16	6.66	25.99	48
D to B	48.75	87.87	16	16.25	54.81	48
Combined: all levels	138.11	85.00	16	28.33	87.90	48
Direct question (B)						
D to E	19.71	37.85	17	6.57	23.38	51
D to C	21.18	42.22	17	7.06	25.93	51
C to B	10.00	29.10	17	3.33	17.14	51
D to B	31.18	64.63	17	10.39	39.46	51
Combined: all levels	50.88	77.46	17	16.96	50.07	51
Direct question: payment card (A)						
D to E	19.71	34.30	17	6.20	20.99	54
D to C	30.88	74.57	17	9.72	43.45	54
C to B	19.71	49.42	17	6.20	28.68	54
D to B	51.18	122.88	17	16.11	71.65	54
Combined: all levels	70.88	127.61	17	22.31	77.59	54

values combined for all respondents were the same as those for users, except for the comparison of bidding games, where the difference was significant only for the Level Dto E change.

Table 4-14 presents the results for the regression models with the user values as the dependent variables. The models generally have less explanatory power than the option price models but do show some limited ability to explain variations in user value. Age and respondent attitude toward paying the cost of water pollution are the key variables in the model, and both have the expected signs.

Table 4-14. Regression Results for User Value Estimates of Water Quality Changes--Protest Bids and Outliers Excluded[a]

Independent variable	Water quality changes: D to E (avoid)	D to C	C to B	Total combined all levels	Total improvements only
Intercept	10.372	1.529	-2.143	6.686	17.058
	(0.551)	(0.070)	(-0.138)	(0.180)	(0.363)
Sex (1 if male)	1.070	-1.625	-0.107	0.121	1.191
(1 if male)	(0.218)	(-0.285)	(-0.026)	(0.013)	(0.097)
Age	-0.236	-0.264	-0.201	-0.507	-0.743
	(-1.761)	(-1.690)	(-1.817)	(-1.918)	(-2.220)[b]
Education	0.193	0.156	0.464	-0.063	0.130
	(0.142)	(0.098)	(0.412)	(-0.023)	(0,038)
Income	0.00001	0.0002	0.00003	0.0002	0.0003
	(0.073)	(0.740)	(0.167)	(0.607)	(0.508)
Direct question	-2.842	-5.766	-4.300	-11.536	-14.378
	(-0.456)	(-0.796)	(-0.836)	(-0.940)	(-0.925)
Iterative bidding game ($25)	-4.769	-10.724	-5.072	-15.588	-20.358
	(-0.803)	(-1.554)	(-1.035)	(-1.333)	(-1.374)
Iterative bidding game ($125)	6.665	-8.540	-3.006	-7.103	-0.438
	(1.014)	(-1.119)	(-0.554)	(-0.549)	(-0.027)
Willing to pay cost of	9.931	10.828	8.116	19.654	29.586
water pollution	(1.988)[b]	(1.866)	(1.969)[b]	(1.997)[b]	(2.374)[b]
(1 if very much or somewhat)					
Interviewer #1	-1.585	4.020	3.029	8.758	7.172
	(-0.157)	(0.343)	(0.364)	(0.441)	(0.285)
Interviewer #2	4.626	13.666	11.118	25.736	30.362
	(0.500)	(1.270)	(1.455)	(1.411)	(1.314)
Interviewer #3	-3.479	27.836	19.108	47.530	44.051
	(-0.395)	(2.721)[b]	(2.630)[b]	(2.740)	(2.005)[b]
Interviewer #4	-9.651	7.079	2.996	9.987	0.336
	(-0.553)	(0.349)	(0.208)	(0.290)	(0.008)
Interviewer #5	-5.724	1.410	-0.087	3.474	-2.250
	(-0.624)	(0.132)	(-0.012)	(0.192)	(-0.098)
Interviewer #6	-6.266	19.835	11.477	27.795	21.529
	(-0.221)	(0.602)	(0.491)	(0.498)	(0.305)
Interviewer #7	12.634	4.664	1.177	16.328	28.962
	(1.225)	(0.389)	(0.138)	(0.803)	(1.125)
Interviewer #8	-5.509	11.417	3.960	15.851	10.342
	(-0.589)	(1.050)	(0.513)	(0.860)	(0.528)
Interviewer #9	-18.707	-3.159	-3.381	-8.995	-27.702
	(-0.889)	(-0.129)	(-0.195)	(-0.217)	(-0.528)
R^2	0.13	0.14	0.14	0.14	0.15
F	1.22	1.34	1.28	1.34	1.44
Degrees of freedom	137	137	137	137	137

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

[b]Significant at the 0.05 level.

4.7 SUMMARY

The contingent valuation estimates of the option price for quality improvements are consistently plausible throughout the various analytical considerations. The empirical results indicate that the methods used to elicit the bid do have a statistically significant effect on the estimates ofan individual's valuation". Payment cards and the bidding game with a $125 starting point produced higher willingness-to-pay estimates than either the direct question or the bidding game with a $25 starting point. There is some evidence of a Starting point bias in the bidding game, but the statistical analyses are not conclusive. The results comparing bidding games with non bidding games indicated no differences when these combined comparisons are made. In terms of future contingent valuation experiments, the results imply that using bidding games to elicit willingness to pay requires a range of starting points to test for starting point bias. No statistical or analytical differences are apparent when nonbidding games are employed to elicit willingness to pay.

For the continued use of the contingent valuation method to estimate benefits of water quality improvements, the general prognosis from the results of the Monongahela River case study is a good one. The empirical models performed reasonably well in explaining variations in willingness to pay, with little indication that individual interviewers influenced the results. The consistently plausible signs and magnitudes of key economic variables suggest that the respondents perceived the realism of the survey and did not experience problems with the hypothetical nature. Moreover, the results came from a random sample of households from an area whose socioeconomic profile is not ideally suited for a contingent valuation survey: The respondents were older, less and poorer than in previous contingent valuation studies.

CHAPTER 5

CONTINGENT VALUATION DESIGN AND RESULTS: OPTION AND EXISTENCE VALUES

5.1 INTRODUCTION

Over a decade ago, Krutilla [1967] emphasized the importance of nonuser benefits to the process of efficiently allocating natural environments. In his development of the special problems associated with valuing the services of natural environments, Krutilla identified several types of nonuser values. The objective of this chapter is to present survey results that attempt to measure directly two of the sources of benefits Krutilla identified--option value and existence value. It should be acknowledged at the outset that the first of these, option value, has received the greatest attention in the literature and is regarded as one of the most important components of nonuser values. As a consequence, the majority of this chapter is devoted to the theoretical and empirical problems associated with modeling and measuring option value.

The simplest approach to defining option value is to use an example. Consider an individual who is uncertain whether he will visit a recreation site on the Monongahela River in the future. Also, suppose this person is uncertain whether the facility will be available in the future should he decide to use it. This uncertainty over availability may arise because the individual either does not know whether the facility will permit any use or does not know the types of uses that will be permitted. (For example, a river may not permit any use, or it simply may not be available for swimming. Of course, the inability to support recreational swimming does not preclude the provision of sport fishing and boating services.) What is at issue is uncertainty over the character of the supply. This uncertainty can involve the all-or-none case, a concept conventionally used in the theoretical literature, or simply a change in the types of uses that can be supported in the future. Given these conditions, a rational individual may be willing to pay some amount for the right to use the facility's services in the future. This payment can be interpreted as a means of insuring access to the site's services. Of course, it does not eliminate the individual's uncertainty over whether he will actually decide to use the site's services.

In all discussions of option value, the payment is assumed to be constant regardless of whether or not the individual visits the site. The payment is usually described as the option price. The option value is defined as the difference between this payment and the individual's expected consumer surplus from having access to the site's services. In the extreme case, where the choice is use or no use, the expected consumer surplus is the weighted sum (by the relevant probabilities) of the consumer surplus associated with access and use of the site plus that of access and no use. Of course, it must be recognized that this discussion assumes that markets do not exist for contingent claims that could handle the prospects for a future demand. Thus, there is no alternative mechanism (other than purchasing the option) available to the individual for diversifying the risk he experiences.

Researchers have generally agreed that this description of behavior is plausible. The literature, however, includes a wide array of arguments concerning the relationship between the maximum willingness to pay for the option and the exDected consumer surplus. For example, Cicchetti and Freeman [1971] observed that option value existed as a direct result of risk-averse behavior and was therefore positive. By contrast, using a similar framework, Schmalensee [1972] concluded that option value may be positive or negative depending on the vantage point selected for evaluating the individual's choices. Subsequent contributions questioned Schmalensee's definition of risk aversion (Bohm [1975]); introduced time specifically into the analysis (Arrow and Fisher [1974]; Henry [1974]; and Conrad [1980]); and, more specifically, considered the mechanisms available to the individual for diversifying risk (Graham [1981]). The result has been a large and often confusing literature.

Understanding the past contributions in this area requires a clear description of three aspects of the role of uncertainty in each model. This characterization of uncertainty is most easily summarized by posing three questions:

- What is the source of the uncertainty in the individual's decision problem?

- How will the uncertainty in this decision problem ultimately be resolved?

- Is it possible to amend the decision process to accommodate new information that may resolve some of the uncertainty?

Each of the past analyses of option value provides implicit answers to these questions. Moreover, the answers help explain why these analyses yield such diverse conclusions.

Two recent papers have provided the elements necessary to integrate a significant portion of the literature. The first of these is a review article by Bishop [1982] that provides an excellent summary of past contributions and extends earlier work by amending Schmalensee's framework to delete the individual's demand uncertainty and to explicitly include supply uncertainty. In the second paper,Graham [1981] seeks to define the appropriate measure of benefits for benefit-cost analyses in the presence of uncertainty. He concludes, as Bohm [1975] did earlier, that option price and not expected consumer surplus is the appropriate valuation measure. Unfortunately, his evaluation of the problem tends to focus on cases where individuals face specific risks and have access to ideal markets in which to diversify these risks. For these cases, he quite correctly concludes option value is largely irrelevant.

Of course, most resource and environmental problems do not "fit" these assumptions. Nonetheless, his framework and evaluation of the case of collective risk provide another important insight into the appropriate treatment of option value.

Section 5.2 of this chapter reviews the modeling of uncertainty and, specifically, the use of a contingent claims framework. This review is necessary to understand the implications of alternative definitions of risk aversion. With this background it is possible in Section 5.3 to describe the "timeless" analyses of option value and to relate them to the recent contributions of Bishop [1982] and Graham [1981]. Section 5.4 briefly discusses the relationship between option value and quasi-option value introduced by Arrow and Fisher [1974].

Section 5.5 discusses three recent attempts to empirical y estimate nonuser values--the Green ley, Walsh, and Young [1981] estimates of option value from potential water quality degradation in the South Platte River basin in Colorado; Mitchell and Carson's [1981] estimates of the total "intrinsic" values for improvements in national water quality; and the Schulze et al. [1981] analysis of visibility benefits for national parks in the Southwest.

Sections 5.6 through 5.8 describe the survey results for the Monongahela River basin. Section 5.6 describes the questions used to estimate option value and to determine its sensitivity to the character of the supply uncertainty. The survey has been structured so that it is possible to distinguish the estimates according to the question used, the level of supply uncertainty, and the character of the respondents. Respondents are grouped according to whether they have used the river for recreation purposes. Section 5.7 presents a summary of the empirical results and an evaluation of the effects of the questioning mode (as well as of the starting point for the iterative bidding scheme) used for the. estimates. In addition to measuring option value, attempts were made to measure existence values independently. Section 5.8 discusses these efforts. Section 5.9 presents a summary of the primary findings of this research.

5.2 CONTINGENT CLAIMS MARKETS AND THE MODELING OF UNCERTAINTY*

The traditional approach to dealing with production and exchange decisions under uncertainty involves a definition of new commodities that specifies not only their physical characteristics, location, and date of availability, but also a particular state of the world that must be realized if the stipulated transaction is to take place. In terms of the example used in Section 5.1, one state of the world permits access to the Monongahela River recreation site and another does not. In this framework, uncertainty has the effect of expanding the commodity set available to the individual. For example, if, in

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*The theoretical analysis in this chapter is an expanded version of that reported in Smith [1983].

the absence of uncertainty, there are N' commodities, and if uncertainty introduces K states of nature, a contingent claims model redefines the commodity set to be N "K contingent claims. Each is a claim to a good contingent upon the state of nature. In this framework, the model is describing how an individual's plans for activities are made rather than the actual activities themselves. These plans involve the selection of claims to goods, should the state of the world be realized. Thus, the individual must allocate his budget optimally among these claims before the state of the world is known.

Of course, defining optimality in this framework requires consideration of the rule that aggregates these claims. Because each of these new commodities involves both a good and a state of world, each outcome needs an associated probability. This permits the use of expected utility--justified in the early work of von Neumann and Morgenstern [1947] --as the rule for aggregating the values associated with these claims. That is, given the four postulates of rational choice, the utility of any set of contingent claims (e. g., a commodity considered over all states of nature) can be derived as the expected utility. * The most important of these postulates for understanding the literature on option value is the uniqueness postulate, which requires the expected utility of a set of claims to be independent of the "state labeling" of the commodities involved in these claims. That is, these commodities could be rearranged over all states of nature without changing the expected utility as long as each commodity is realized with the same probability.

Most analyses of option value drop this postulate by assuming that the individual has a different utility function depending on whether the services of a recreation site are demanded or not demanded. The presence of a positive level of demand for the site is not simply a reflection of a higher income or a lower price. With a given income and prices of substitute goods, conventional statements of an individual's demand function often assume that there is a price at which the services of a site will not be demanded. With a state-dependent demand specification it is unlikely that the reasons why the site will not be demanded can be fully explained. Rather, this specification is used simply to reflect a different set of preferences that depend on the existence of demand for the site. To emphasize this assumption, the following review summarizes the difference between the consumer's" allocation decisions (among contingent claims) and the definition of risk aversion under the two frameworks--one that maintains the uniqueness postulate and one that does not.

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*The four postulates are: (1) ordering and preference direction--larger incomes are preferred to smaller incomes; (2) certainty equivalence--there is an amount, the certainty equivalent, that is intermediate in size to the largest and smallest consequences of a given prospect; (3) independence--a claim, designated as Z, can be substituted for its preference equivalent, say Z, in any prospect into which Z enters and vice versa; and (4) uniqueness--the certainty equivalent of a prospect depends only on the magnitudes of the probabilities and incomes, not on their state designations. See Hirshleifer {1970, pp. 219-20] or Malinvaud [1972, pp. 285-90] for further discussion. Cook and Graham [1977] provide additional perspective for irreplaceable goods.

Consider the case of two continent commodities (or claims), X_1 and X_2, corresponding to States 1 and 2 and having probabilities of P and (l-P), respectively. If the prices of these claims are r_1 and r_2, and if utility is dependent 'n the amount of X_1, such as $u(X_i)$, the individual's objective function, when the uniqueness postulate late is satisfied,can be written as Equation (5.1):

$$V = p\mu(X_1) + (1-p)\,\mu(X_2)\ , \tag{5.1}$$

where V is the expected utility. If the initial endowment of claims is $(\bar{X}_1, \bar{X}_2)$, the budget constraint limiting the individual's choices would be:

$$Y = r_1X_1 + r_2X_2 = r_1\bar{X}_1 + r_2\bar{X}_2\ . \tag{5.2}$$

Maximizing Equation (5.1) subject to Equation (5.2) and solving the first-order conditions yields the familiar equality of relative prices and probability-weighted marginal utilities, as in Equation (5.3)*:

$$\frac{pu'(X_1)}{(1-p)u'(X_2)} = \frac{r_1}{r_2}\ . \tag{5.3}$$

This result is usually specialized further by consideration of a "fair" gamble case (i. e., where 'p dX_1 + (1 - p)dX_2 = 0). This case implies the equality of the probability ratio and the price ratio for the two contingent claims (i. fe. , $p/(1 - p) = r_1/r_2$). † Using this condition, Equation (5.3) can be rewritten as:

$$\frac{u'(X_1)}{u'(X_2)} = 1\ . \tag{5.4}$$

The optimal allocation calls for equal claims in X_1 and X_2, as given by the point R in Figure 5-1. Thus, the selection in this case will fall along the certainty locus (both income and utility)--the 45° line in Figure 5-1.

The traditional definition of risk aversion for this framework maintains that risk-averse individuals require better than "fair" gambles before they will select these alternatives over a certain claim with the same expected income. Under the assumption of uniqueness there are two further implications

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*The second-order conditions are $d^2X_2/dX_1^2 > 0$. This can be shown, given uniqueness, to be implied by the assumption of concavity of u(.). That is: $d^2X_2/dX_1^2 = \partial/\partial X_1\,(dX_2/dX_1) + \partial/\partial X_2\,(dX_2/dX_1)\,[dX_2/dX_1]$, where $dX_2/dX_1 = -[p/(1-p)]\cdot[u'(X_1)/u'(X_2)]$, hence $d^2X_2/dX_1^2 = p\,u''(X_1)/(1-p)\,u'(X_2) - p^2(u'(X_1))^2u''(X_2)/(1-p)^2(u'(X_2))^3$. Concavity of u(.) implies that u"(.) < 0, and thus d^2X_2/dX_1^2 is positive, because p, (1-p), U'(Xl), and $u'(X_2)$ are all positive.

†This conclusion is derived by recognizing the implications of a constant initial budget and the "fair" gamble for selections of contingent claims: A Constant budget implies $r_1dX_1 + r_2dX_2 = 0$; a fair gamble implies $pdX_1 + (1-p)dX_2 = 0$; thus, a fair gamble implies $-dX_2/dX_1 = p/(1-p) = r_1/r_2$.

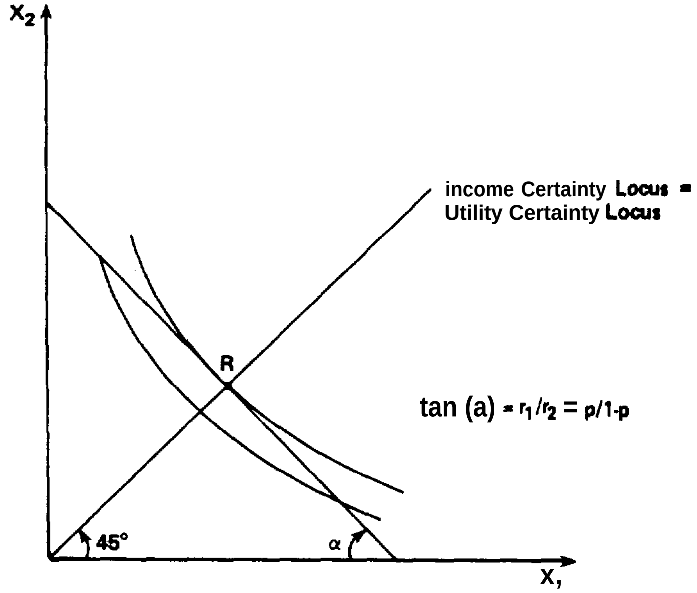

Figure 5-1. Optimal allocation of choice with contingent claims.

associated with risk-averse behavior. They are important because they provide the means for explaining the divergence between Schmalensee [1972] and Bohm [1975] in their respective interpretations of the appropriate definition of risk aversion. To understand these diverqent interpretations, imagine a risk-averse individual subject to the choice of X with certainty versus the prospect of X_1 with probability p and X_2 with probability (1 - p). Assume $X = pX_1 + (1 - p)X_2$. Then a risk-averse individual's choice would be consistent with a utility function that ranks these prospects as follows:

$$u(\bar{X}) \geq pu(X_1) + (1 - p)\, u(X_2) \tag{5.5}$$

Equation (5.5) will be realized if u(.) is concave. Thus, the concavity of u(.) is usually taken to imply risk aversion. In this study's analysis of "fair" gambles, as given in Equation (5.4), the risk-averse individual's choices can also be characterized as implying an allocation of resources among claims such as $u'(X_1) = u'(X_2)$. All individuals will allocate their resources among claims to States 1 and 2 so that these marginal utilities are equalized in the case of "fair" prices. Since risk aversion is defined by the concavity of u(.), the behavioral responses of a risk-averse individual will be determined by how he responds to a change in p. However, once the assumption of uniqueness is relaxed and state-specific utility functions are permitted, the condition for fair gambles implies only that the marginal utilities will be equalized and not that either the total utilities or the total monetary claims in each state will be equalized. Without uniqueness there will be a distinction between the locus of equal consumption (or income) over states (i.e. , the 45° line defined as the income and utility "certainty" locus under the assumption of uniqueness) and the utility certainty locus, where $u_1(X_1) = u_2(X_2)$, as illustrated in Figure 5-2. Moreover, the optimal allocation will not necessarily lie on the utility certainty locus as it did under the assumption of uniqueness. Schmalensee [1972] mis-

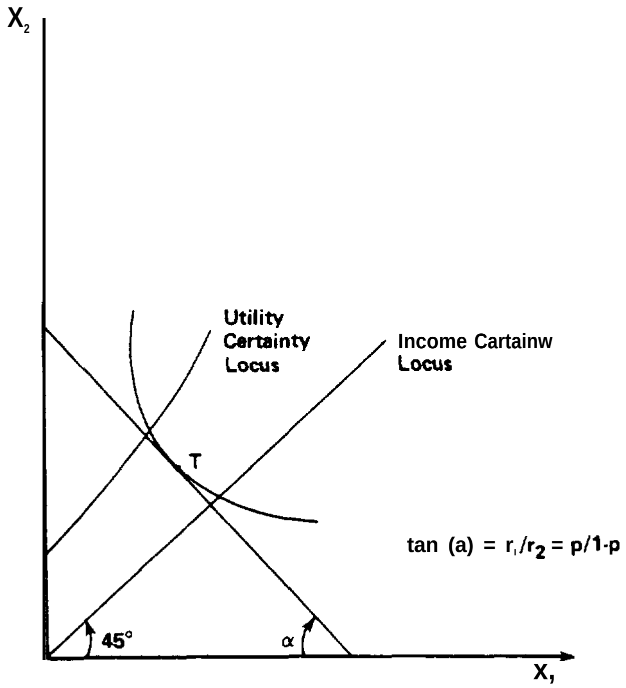

Figure 5-2. Optimal allocation of choices of contingent claims without uniqueness.

interpreted this possibility as an indication that concavity was an inappropriate definition of risk aversion and selected the equality of marginal utilities as the characteristic necessary to define risk-averse behavior in the case of State-dependent utility functions. In summary, the contingent claims model provides an analytical vehicle that will aid in deciphering the misunderstandings of option value that have developed in the research literature.

5.3 OPTION VALUE: THE "TIMELESS" ANALYSES

The first analytical evaluations of option value employed a "timeless" framework with the only source of uncertainty associated with the state of the individual's preference structure (see Cicchetti and Freeman [1971], Bohm (1975], and Schmalensee [1972, 1975]). To simplify the explanation of these analyses, assume that individual preferences can be described by just two states: State 1, which demands the services of the asset with u_1 (.), and State 2, which 'does not demand the services of the asset with u_2(.). Each state's utility function will have two arguments -- income, Y, and a variable indicating access to the asset's services, with d implying the services are available and d implying they are not. This argument can proceed using the compensating variation definitions of consumer surplus, option price, and option value, but comparable arguments can be developed using equivalent variation.

Equations (5.6) and (5.7) define consumer surplus for the i^{th} state (SC_i) and option price (OP), respectively:

$$u_i(Y_i - SC_i, d) = u_i(Y_i, \bar{d}), i=1,2 \tag{5.6}$$

$$\sum_{i=1}^{2} \pi_i u_i(Y_i - OP, d) = \sum_{i=1}^{2} \pi_i u_i(Y_i, \bar{d}) \tag{5.7}$$

where

$u_i(Y, d)$ = individual utility for State i with income Y_i and with access to the services of the asset

π_i = probability of utility State i ($\pi_2 = 1 - \pi_1$).

Substituting Equation (5.7) in Equation (5.6) and rearranging terms gives:

$$\sum_{i=1}^{2} N_i [u_i(Y_i - OP, d) - u_i(Y_i - SC_i, d)] = 0 . \tag{5.8}$$

Schmalensee [1972] proposed using concavity of the state-specific utility functions to expand Equation (5.8). That is, the inequalities given in Equations (5.9) and (5.10) hold for concave $u_i(.)$:*

$$u_i(Y_i - OP, d) - u_i(Y_i - SC_i, d) > (SC_i - OP) [\partial u_i/\partial Y_i (Y_i - OP, d)] \tag{5.9}$$

$$u_i(Y_i - OP, d) - u_i(Y_i - SC_i, d) < (SC_i - OP) [\partial u_i/\partial Y_i (Y_i - SC_i, d)]. \tag{5.10}$$

Substituting each into Equation (5.8) and rearranging terms gives inequalities for option price involving Bohm's [1975] weighted expected consumer surplus terms as Equations (5.11) and (5.12):

$$OP \geq \sum_{i=1}^{2} \pi_i SC_i [\partial u_i/\partial Y_i (Y_i - OP, d)] / \sum_{i=1}^{2} \pi_i [\partial u_i/\partial Y_i (Y_i - OP, d)] . \tag{5.11}$$

$$OP \leq \sum_{i=1}^{2} \pi_i SC_i [\partial u_i/\partial Y_i (Y_i - SC_i, d)] / \sum_{i=1}^{2} \pi_i [\partial u_i/\partial Y_i (Y_i - SC_i, d)]. \tag{5.12}$$

Because option value (OV) is defined as the difference between the option price (OP) and the expected consumer surplus (SC) --i.e. , OV = OP

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*In the analysis that follows, the point of evaluation of the partial derivatives will be important to the interpretation given to each relationship. Therefore, $[\partial u_i/\partial Y (a, b)]$ will refer to the partial derivative of $u_i(.)$ with respect to Y evaluated at the point (a, b).

$-\left(\sum_{i=1}^{2} \pi_i SC_i\right)$--these inequalities offer the potential for determining the sign of the Option value if it is possible to relate the weighted consumer surplus to the expected value of the consumer surplus. * Schmalensee's definition of risk aversion as equality of the marginal utilities of income across states (i. e., $\partial u_1/\partial Y_1 = \partial u_2/\partial Y_2$) provides the ability to make this association by making the weights in Equations (5.11) or (5.12) unity. That is, depending upon whether the equality is realized at Y_i - OP or Y_i - SC_i, option price will be greater or less than expected consumer surplus. Thus, Schmalensee concludes that the sign of option value depends on the point of evaluation.

AS observed earlier, Bohm has correctly observed that this judgment is misleading for at least two reasons. First, the interesting expression is Equation (5.11) because the point of evaluation of the marginal utilities correctly assigns the individual the relevant income/access conditions. This expression describes the relationship between option price and expected consumer

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*To illustrate this point let

$$W_1 = \frac{\pi_1 \frac{\partial u_1}{\partial Y_1}(Y_1\text{-OP, } d)}{\sum_{i=1}^{2} \pi_i \frac{\partial u_i}{\partial Y_i}(Y_i\text{-OP, } d)}$$

$$W_2 = \frac{\pi_2 \frac{\partial u_2}{\partial Y_2}(Y_2\text{-OP, } d)}{\sum_{i=1}^{2} \pi_i \frac{\partial u_i}{\partial Y_i}(Y_1\text{-OP, } d)}$$

This specification will imply $W_1 + W_2 = 1$. Consequently, Equation (5.11) can be rewritten as

$$OP \geq \sum_{i=1}^{2} W_i sc_i$$

To compare the specification with the expected consumer surplus $\left(\sum_{i=1}^{2} \pi_i Sc_i\right)$ requires some knowledge about the relationship between W_i and π_i. For example, if it is assumed that $\frac{\partial u_1}{\partial Y_1}(Y_1 - OP, d) = \frac{\partial u_2}{\partial Y_2}(y_2 - OP, d)$ (the marginal utilities of income are equal in each period), then $W_i = \pi_i$ and Equation (5.11) option value to be signed.

surplus when the individual's income is reduced by the option price. As Bohm suggested:

> We are asking him how much he can abstain from today in terms of an OP and enter the future state, whatever it may be, with a disposable income of Y-OP without being worse off. He will be at Y-SC_i only if he does not pay an option price--and that is another story. We do not ask him about the maximum amount he is willing to pay provided he does not pay that amount. (Bohm [1975], p. 735)

The second consideration involves the Schmalensee definition of risk aversion. The previous section noted that the conventional definition of risk aversion, with the uniqueness assumption for state utility functions, simultaneously implies that:

- The utility function must be concave to admit such a response to a "fair" gamble.
- In response to a fair gamble the risk-averse individual will always select a point w-here marginal utilities of income are equal.

This latter point is a result of optimizing behavior in the presence of a fair gamble and concavity of the utility functions. Once the uniqueness assumption is relaxed and state-specific utility functions are permitted, the only plausible definition for risk aversion is by the concavity of the state-specific utility functions. Thus, when the correct point of evaluation (i. e., the inequality given in Equation [5.11]) and the appropriate definition of risk aversion are used, the sign of option value cannot be established. It may be positive, negative, or zero depending upon the relationship between the marginal utilities of income at each state.

Given these conclusions, how do Cicchetti and Freeman [1971] establish, apparently unambiguously, a positive sign for option value while Bohm does not? To answer this question, return to the example of a "fair" gamble with state-specific utility functions that was given in Figure 5-2. Schmalensee incorrectly interpreted this divergence to indicate the inadequacy of u.(.)'s concavity as the sole basis for defining risk-averse behavior. However, Cicchetti and Freeman apparently intended to focus on a comparison along the utility certainty locus. * As Anderson [1981] has recently observed, they as-

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*Cicchetti and Freeman seem to have wanted to use the utility certainty locus to make the state-specific actions commensurate. This can be seen in their proposal that:

> To make the choice problem solvable, there must be some way of making the utilities of the two alternative mappings commensurable. We have proceeded as follows to derive a rule for comparing the utilities from the two alternative mappings. For any level of disposable income, if the individual did not demand the

sumed that the individual's income was equal across all states and that, when income was equal, total utilities in each state were also equal at the preferred price vector. In the present analysis, this would correspond to equal utility for conditions of access to the resource [i. e., $u_i(Y_i, d) = u_j(Y_j, d)$ for $Y_i = Y_j$]. Unfortunately, the Cicchetti-Freeman analysis did not correctly describe an individual's choices of Y and the services of the asset. While they proposed to consider a discrete choice similar to the d versus $\bar{d}$ description, they represented the services as continuously available, designed by X.

Figures 5-3 and 5-4 reproduce the Cicchetti-Freeman figures (III and IV) for the analysis. If Figure 5-4 is interpreted as an illustration of the "no-demand" case, the assertion that $u_8 = U_5$ at Y. is incorrect. If the relevant budget constraint, B_1, is considered, the individual will not choose to consume the same level of Y. In the "no-demand" case (i.e. , u_8), the selected income will be Y_0, but the "demand" case will be Y_5 in Figure 5-3. Similar arguments can be developed for the assumption that $u_1 = u_6$ at Y. - OP_1, which indicates that the" construction of Figure 5-4 is incorrect. To adequately deal with the equivalence of state-specific utility functions at equal income levels, a graphical analysis must be in terms of indirect utility functions as described by Bishop [1982]. In this case the ambiguity in the sign of option value is clearly demonstrated.

In Graham's [1981] recent attempt to use the Schmalensee framework to comment on the appropriate treatment of option value, he argues that the reasonableness of using option price for benefit-cost analyses will depend on the nature of the problem under study. More specifically, Graham concluded that:

- Option price is the appropriate benefit measure for project analysis when one can assume the individuals affected are similar and they all experience the same risk.

- Expected willingness to pay will be the appropriate measure for those cases with similar individuals but with risks specific to each.

These conclusions are derived using a generalization of the option price definition (Equation (5.7)). To understand them, Graham's arguments must be considered in detail. For the case of individual risks, he assumes that payments may be state specific. This is equivalent to the assumption that a complete set of markets for contingent claims exists. Under these assumptions, the definition of option price in Equation (5.7) would be replaced by Equation (5.13):

> good, he would choose a consumption point on the Y axis and experience a certain level of utility; if he were to demand the good (assuming that it is available), he would choose a tangency point on the budget line associated with that point, and experience a given level of utility. We assume that the alternative outcomes have the same utility. (Cicchetti and Freeman [1971], p. 534)

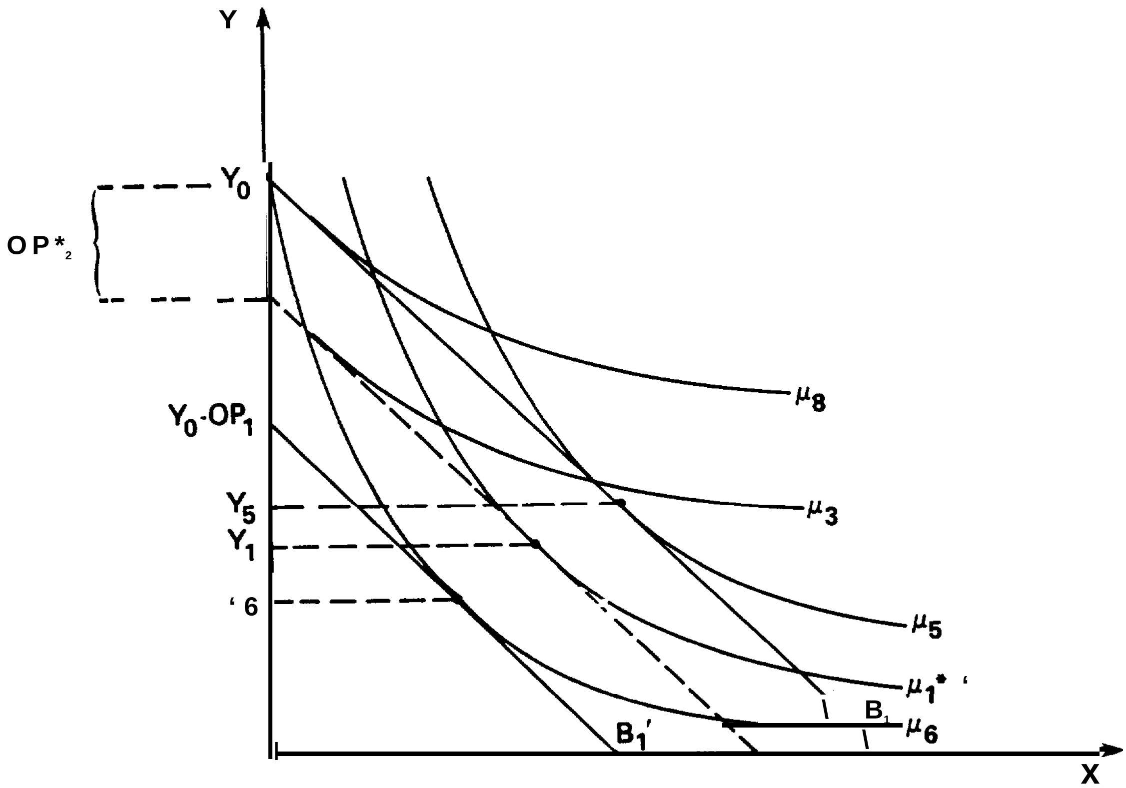

Figure 5-3. Option value in Cicchetti-Freeman's analysis.

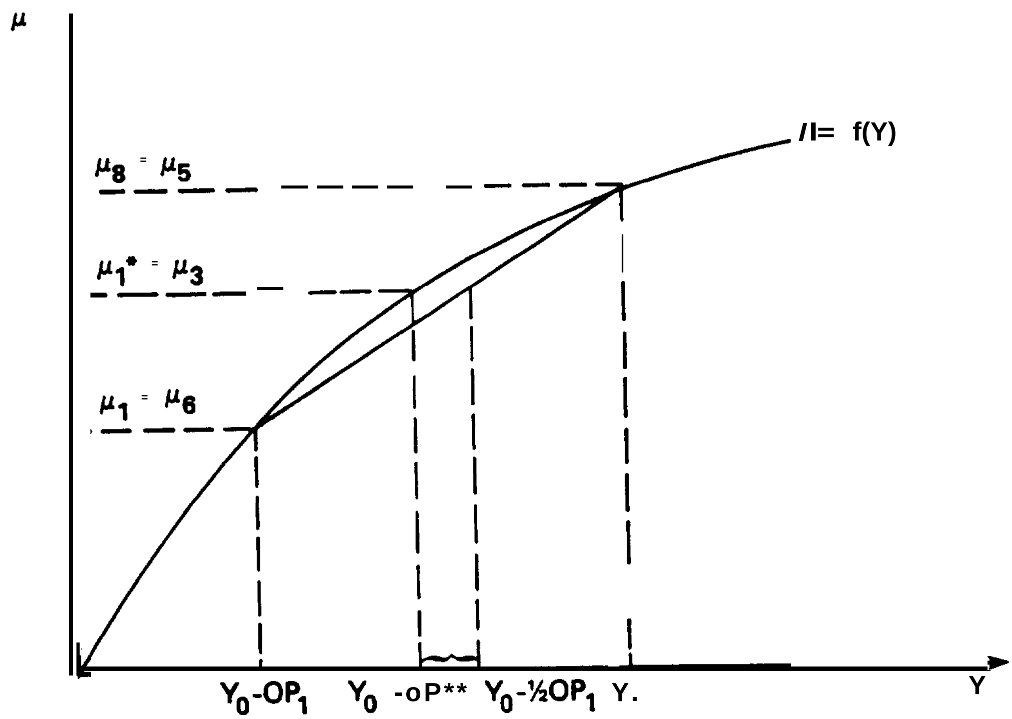

Figure 5-4. Option value in Cicchetti-Freeman's analysis with "no demand."

$$\sum_{i=1}^{2} \pi_i u_i(Y_i - P_i, d) = \sum_{i=1}^{2} \pi_i u_i(Y_i, \bar{d}) \quad (5.13)$$

Graham defines this relationship as the willingness-to-pay locus. The special case of $P_1 = P_2 = OP$ would yield the conventional definition of the option price. The locus also includes the point where $P_i = SC_i$ (by construction), as well as the fair-bet and the utility certainty points, as illustrated in Figure 5-5.

To illustrate some of the points on the locus; assume TT' corresponds to the individual's budget constraint where the Prices of claims in States d and d correspond to the probabilities of each state. F will then designate the fair-bet pOint. When payments are constant, regardless of the state of nature, as with point P, the locus describes the willingness to pay under institutional conditions consistent with an option price, OP. Point S corresponds to the coordinates of the consumer surpluses for each state. To calculate the expected value of the consumer surplus, the budget constraint through S parallel to TT' is used (to reflect the state probabilities). The intersection of this new budget line, RR', with the 45° line defines the expected consumer surplus. For this example, option value is positive.

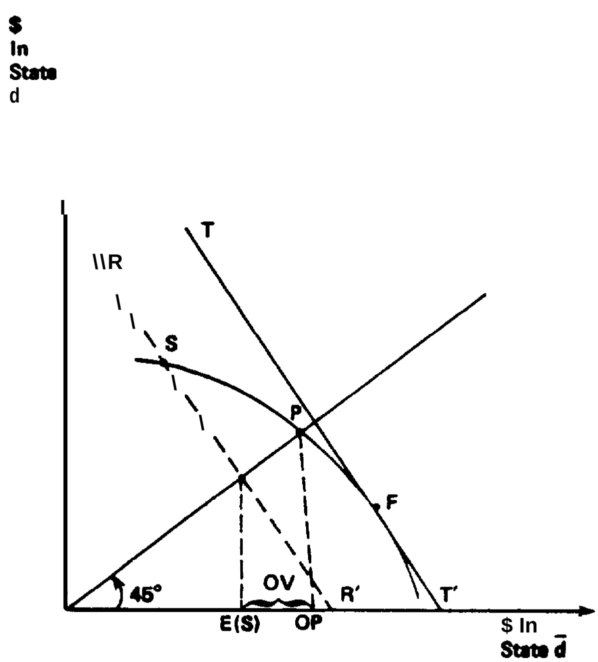

Figure 5-5. Option value with contingent claims in Graham's analysis.

Aggregating the willingness-to-pay loci across individuals, Graham argued that:

> Justification of the project hinges upon the question of whether or not contingent prices exist at which aggregate willingness to pay in each state exceeds the corresponding resource cost of the project. Should such prices exist, that point from an individual's locus which has the greatest value at these prices is the one relevant for cost-benefit analysis, and the corresponding value at these prices is the appropriate measure of benefit. (Graham [1981], p. 719)

To apply this approach in particular examples requires that one distinguish: (1) the benefits realized as a result of moving from an initial distribution of income to another that assures an efficient distribution of risk and (2) the benefits resulting from the project itself.

Graham's conclusions are based on two rather special cases. The first of these avoids the issue of an inefficient distribution of risk by assuming that individuals are alike and that they face identical risks. The second case also skirts this issue by assuming the existence of either complete contingent claims markets or an ideal, state-dependent tax collection scheme (tied to the project under evaluation). In either case, an efficient distribution of risk will be realized. Of course, neither of these sets of assumptions is plausible in most applications, where some attempt must be made to include a measure of the value of an option to use the services of an environmental resource. Consequently, as Graham acknowledges, one is left with option price as the "best" basis for measuring benefits. Thus, for practical purposes, Graham's analysis has strengthened Bohm's conclusion: Option price is the relevant focus for applied welfare economics.

Given these conclusions, why worry about the sign and magnitude of option value? One pragmatic reason arises with the difficulty in measuring each individual's option price. If it is possible for wide classes of assets and their associated prospective users to demonstrate that the corresponding option values of the assets would be positive, one would be safe in assuming that measures of the expected user benefits (i.e. , as derived from an "ideal" consumer surplus calculation) would <u>understate</u> the total benefits provided by the asset. *

5.4 THE TIME-SEQUENCED ANALYSES

Time-sequenced evaluations of option value offer more specific answers to the three questions raised at the outset. That is, these analyses provide an explicit statement of the relationship between decisions over time. In general, the uncertainty is supply related. It is resolved with the passage of time, and decisions cannot be altered. The first of these models was devel -

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*This argument ignores the potential role of existence values as described by Krutilla [1967] and more recently discussed by Freeman [1981] oped by Arrow and Fisher [1974], whose framework introduced a time-sequencing of decisions and, as a result, assumed there was a resolution of the uncertainty facing the decision process with the passage of time. Their model considered decisions to develop or preserve a fixed amount of land. Decisions to develop some fraction (or all) of the land were irreversible. Therefore, any information acquired with the passage of time could affect only the decisions made on the remaining stock of preserved land.

Arrow and Fisher's quasi-option value can be interpreted as the expected value of the information obtained through delay, as has been suggested by Conrad [1980] and, indeed, acknowledged earlier by Krutilla and Fisher [1975] in their overall evaluation of special problems associated with allocation decisions involving unique natural environments. For example, Krutilla and Fisher observed that:

> The key new element in Arrow and Fisher is a Bayesian information structure. The passage of time results in new information about the benefits of alternative uses of an environment, which can in turn be taken into account if a decision to devote it to development is deferred. Since development is not reversible, once a decision to develop is made, it cannot be affected by the presence of new information which suggests that it would be a mistake in the future. The main result of the analysis is then that there is an option value, or quasi-option value, to refraining from development--even on the assumption that there is no risk aversion, and only expected values matter. (Krutilla and Fisher [1975], pp. 70-71)

Conrad also suggested that option value could be interpreted as the expected value of perfect information. In so doing, he implicitly maintains that over time one progressively learns of and resolves the uncertainty. However, his conclusion is correct only if it is regarded as the only appropriate translation of the "timeless" analysis of option values into a time-sequenced decision process. Henry [1974] has drawn a similar conclusion in his evaluation of the importance of this transition, noting that:

> The relationship so established between risk aversion and option-price appears rather obvious when it is viewed as being encountered in a 'timeless world' where I [the individual] has one and only one decision to take; in a world of this type any decision is just as irreversible as any other [emphasis added] and it is impossible to introduce Krutilla's option value which is nothing but a risk premium in favour of lirreplaceable assets'. Krutilla's idea can only be examined in a 'sequential world' where ~ [the individual] really has a succession of decisions to take. (Henry [1974], p. 92)

Thus, if it is assumed that uncertainty is resolved over time, that the asset under consideration is in some respect irreplaceable, and that the decisions are made sequentially with the benefit of the acquired information, there is clearly a positive option value. If, on the other hand, the resolution of the uncertainty is not allowed as a part of a set of decisions, option value will be a reflection of risk aversion, and its sign will depend on the nature of the state-specific utility functions.

This distinction has important implications for any attempts to develop estimates of option price. If a direct survey or contingent valuation method is used to obtain these estimates, the results will be based on hypothetical conditions in which it is unlikely that respondents can be given a means of obtaining information and reacting to it. That is, as a practical matter, it is probably safe to assume that questions designed to elicit an individual's option price will not be posed in a way that identifies mechanisms through which the individual can obtain information and alter decisions based on it. Thus, the timeless analyses are more likely to be the relevant models for understanding the empirical measurement of option value. However, this judgment does not imply that a careful description of the source of uncertainty and the means through which it is resolved can be ignored in question design. Rather, it simply recognizes that formulating questions that acknowledge the prospects for learning and that offer mechanisms for enhancing learning would likely increase the complexity of the instrument to a point where it was not usable.

Together with extensions of it in Smith [1983], this analysis suggests that supply uncertainty can be important to the sign of option value in a timeless framework. Accordingly, supply uncertainty should be acknowledged and explicitly identified in questionnaires designed to measure option price.

5.5 RECENT ESTIMATES OF NONUSER VALUES

There appears to have been only one published study estimating option values. This study by Greenley, Walsh, and Young [1981] attempts to measure the option value for the recreational use of preserved water quality in the South Platte River basin in Colorado. These authors used two payment vehicles--an increment to the sales tax and an increase in the monthly water-sewer fee--in a survey of a random sample of 202 residents of Denver and Fort Collins. Their study attempted to estimate specific components of the benefits of maintaining water quality, including option, user, existence, and bequest values. Their paper focuses on the results of the question for option value. Two aspects of their option value question are important. First, it seems to be eliciting an option price, not option value, and specifies a resolution of the supply uncertainty associated with the preservation of water quality. And, second, the question treats the two payment vehicles differently. The question is reproduced below:

> Given your chances of future recreational use, would you be willing to pay an additional _____ cents on the dollar in present sales taxes every year to postpone mining development? This postponement would permit information to become available enabling you to make a decision with near certainty in the future as to which option (recreational use or mining development) would be most beneficial to you. Would it be <u>reasonable</u> to add ______ to your water bill every month for this postponement? (Greenley, Walsh, and Young [1981], p. 666, emphasis added)

as discussed earlier, option value is the difference between an individuals option price and his expected consumer surplus. It would seem that this question is soliciting the option price. Unfortunately, the authors interpreted the responses as measures of the option value and asked a separate question intended to obtain user values. The Greenley Walsh, and Young results with the sales tax payment vehicle indicate an average option value of approximately $23.00 per year (with the water fee payment vehicle, it was $8.90).*

The interpretation of these results has been somewhat controversial . Both questions used by Greenley, Walsh, and Young seem to be asking for an option price --the first under a timeless interpretation and the second under a time-sequenced format. Greenley, Walsh, and Young interpret one as a measure of expected consumer surplus and the other as option value. Mitchell and Carson [1981] appear to have been the first to question the interpretation of the Greenley, Walsh, and Young questions. While Mitchell and Carson did not relate their criticisms to the two conceptions of option value, they did argue that both questions measure option price. Moreover, they suggested that the Greenley, Walsh, and Young results indicate the possibility of a starting point bias, based on the differences in designated starting points used for each payment vehicle. In a recent unpublished response to the Mitchell-Carson comments, Greenley, Walsh, and Young [1983] argue that the interviewing process itself prevented interpretation of the questions as requesting option price. They observe that:

> Some confusion may arise when expected consumer surplus and option value questions are taken out of the context in which they are used because they often take the same general form as questions asking for option price. . . . The important distinction in this case [their study] is that a population of users was first asked to estimate their expected consumer surplus, and in addition, a separate estimate of option value. They were informed that these are separate and distinct values, and provided the opportunity to adjust values previously reported. The respondents provided well-focused estimates for each question. We conclude that the procedures employed in our study capture, reasonably accurately, the values necessary to assess the recreational benefits of improved water quality. " (Greenley, Walsh, and Young [1983]).

While this may be the case, no explanation is offered of why the households adjust their two bids. If each is measuring what the authors intended, there would be no basis for adjustment. Equally important, one can judge the responses to a contingent valuation experiment based only on the questions posed. If they are not clearly connected to the concept desired, there is reason to question whether informal discussions between the interviewer and respondent will assure understanding. Finally, our evaluation of the questions (in contrast to Mitchell and Carson) leads to the conclusion that two different concepts of option price are in fact asked.

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*It should be noted that these summary statistics include all zero bids--both the “true” zero bids and the zero bids of those individuals who refused to participate in the bidding game.

Of course, in fairness to all participants in the exchange, there is no complete record of exactly what the interviewers discussed with survey respondents. Greenley, Walsh, and Young's [1983] recent notes on the Mitchell-Carson critique suggest that they were aware of the potential ambiguity in their questions. What is at issue is not only how successful the interviewers were in overcoming it but also that the terms of the contingent market may differ for each respondent (because of the interviewer effect) making the results problematical.

The second empirical study focusing on user and nonuser values was conducted by Mitchell and Carson [1981]. It sought to measure each individual's willingness to pay for cleaning up all rivers and lakes in the United States to a particular level. Since individuals were not classified according to whether or not they used these water resources, the responses must be assumed to include both use and nonuse values. * Indeed, Mitchell and Carson argue that it is beyond the capability of many respondents to reliably determine separate values for subcategories of water quality benefits. Their survey was based on a national probability sample of 1,576 individuals and was conducted as part of an opinion poll soliciting these individuals' responses to other questions associated with environmental attitudes. This study introduced the water quality ladder used in the survey conducted for the present study. In addition, it assumed that the household payment vehicle was through higher prices and taxes (the same vehicle used in this survey). Four versions of an anchored payment card were used, rather than an iterative bidding framework. They were differentiated according to the range of values reported on the cards and by the anchor points reported. The cards were distinguished by income class so that the anchored values on the card corresponded to the average of the actual payments made by members of each incom-e group. The four sets of anchor points used in this study were:

<u>Version</u>

A — Average household expenditures (through taxes) to the space program, highways, public education, and defense.

B — Same four public goods as in Version A plus police and fire protection.

C — The same four public goods as in Version A, but amounts increased by 25 percent for each income group over the levels used with Version A.

D — The same four public goods and amounts as in Version A plus the estimated amount for water pollution control.

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*Since individuals do not conceive of using all rivers and lakes in the United States, it must be assumed that only a subset of these can be considered a part of the set actually used or planned for future use. To the extent that individuals express a willingness-to-pay bid for improved water quality at all water bodies, they are expressing expected user values, any option values (associated with uncertain future use), and existence values.

Table 5-1. Summary of Mitchell-Carson Estimated Mean[a] Annual Willingness to Pay by Version and Water Quality

Water quality category	Version of payment card		
	A (274)	B (255)	C (244)
Boatable	$168	$133	$161
Fishable	$214	$180	$198
swimmable	$247	$212	$222

[a]This table was summarized from Mitchell and Carson's [1981] Table 5-1, p. 5-3. The numbers in parentheses are the numbers of respondents providing values to the water quality questions for each version in 1980 dollars.

For three of the four versions of the payment card, Table 5-1 reports the mean estimates for boatable, fishable, and swimmable water qualities. * While this study provided detailed analysis of potential survey biases, its questions relate to an abstract conception of the impacts of a water quality improvement for the individual. That is, while the water quality is described as improving to levels defined by the activities--swimmable, fishable, and beatable--the quality of the water already available to the individual is unknown. If the water bodies available to the individual have quality levels that permit the full range of his desired uses, the responses might be expected to reflect an existence value for all other sites. By contrast, if the available sites for water-based recreation do not permit all or some subset of these activities, the responses may reflect user values. Without knowledge of these site-specific features, Mitchell and Carson must average heterogeneous responses. That is, ideally, the responses based on user values and those associated with nonuser values should be distinguished. Moreover, the analysis should control the influence of the differential availability to individuals of sites with the desired water quality. The Mitchell-Carson method implicitly assumes all individuals will benefit equally from the uniform improvement of the water quality at all sites. This may not be correct. The benefit realized by each individual will depend on his access to sites with the desired water quality before the change.

Mitchell and Carson estimate the nonuser benefits of water quality improvements by assuming that the willingness-to-pay responses of surveyed

*The effects of knowing what was actually paid for water quality control (i. e., version D) were also reported by the authors. Forty-seven percent of the 354 respondents to version D said they were willing to pay the amount shown on the card that they were told would raise water quality to fishable in the next few years. For further details on these results, see Mitchell and Carson [1981, pp. 5-6 to 5-7]. The figures are not reported here since they reflect only that some people were willing to pay at least these amounts.

individuals who did not engage in in-stream recreation will be "almost purely intrinsic in nature. " Even if this reasoning is correct, it does not imply that nonuser willingness to pay will be a reasonable estimate of option value. It may include existence values as well. Nonetheless, based on this logic, 39 percent of the respondents with willingess-to-pay data reported they had no in-stream use of freshwater in the past 2 years. The nonusers mean bid for fishable water was $111. The mean bid by users for the same water quality change was $237. Hence, by these estimates, intrinsic values were judged to be approximately 45 percent of total willingness to pay of users.

Rae [1981a, 1981b] has also reported estimates of option price for "clear" visibility conditions for future visits of current users in two separate onsite surveys in 1981 at the Mesa Verda National Park and Great Smoky National Park. His analysis was conducted along with a contingent ranking evaluation of the benefits of improving visibility conditions (see Chapter 6 for a more complete summary). A payment card was used as the instrument, and respondents were asked how much they would pay for an insurance policy to guarantee clear visibility conditions for all visits to the park. Prices on the card ranged from 0 to $10 in increments of $0.25. The average bid was $4.17 for Mesa Verda respondents and $5.96 for Great Smoky respondents (estimates in 1981 dollars). Rae interprets this as a present value option price, and uses estimates of current user values for visibility improvements derived from the contingent ranking framework to estimate option value.

To make Rae's interpretation requires assumptions concerning the individual's rate of time preference and probabilities of future visits. Rae uses different assumptions in estimating option value in the two studies. For the Mesa Verda case, he assumed a zero discount rate and one future visit while, with the Great Smoky case, he postulated an 8 percent discount rate and a 0.77 probability of one return visit after 5 years. The expected user values estimated for the two cases were $3.00 and $5.00, respectively. Both sets of assumptions assure a positive estimate of the option value.

In order to evaluate these estimates, the Rae methodology for estimating user values with the contingent ranking framework must be considered. In the next chapter we will discuss, in detail, the use of the contingent ranking approach for benefit measurement. Equally important, the formulation of the question for option price is somewhat vague in its specification of the terms of payment for the insurance. It has been interpreted as a one-time payment in the analysis. Given that all the other components of the survey related to fees associated with use, this distinction may not have been appreciated by the survey respondents.

Finally, the estimation of option value requires assumptions on the time horizon, future level of use, future probabilities of each level of use, and the individual rate of time preference. Rae's example calculation was intended to illustrate the required calculations. Unfortunately, there is little basis for assuming values for each of these variables for his survey respondents.

The last empirical effort at measuring nonuser benefits for an environmental amenity is the Schulze et al. [1981] analysis of visibility at four national parks. This survey was structured to distinguish users from nonusers of the Grand Canyon. Each group was asked different questions. The users were asked about the effects of visibility on their user values, while the nonusers were asked about preservation values. The questions related to visibility at four national parks, to the overall region, and to an evaluation of the willingness to Pay to avoid a visible plume. The respondents were drawn from four cities: Los Angeles, Albuquerque, Denver, and Chicago. Questionnaires for users employed a park fee as the payment vehicle, while nonusers were queried about their willingness to pay for preservation values through electric utility bill increases.

Their results suggest a substantial preservation value (in 1980 $) ranging from $3.72 (the average value for preserving visibility at the Grand Canyon by Denver respondents) to $9.06 (the average for Chicago respondents) per month. These are substantially greater than the estimated user values, which ranged from $0.99 to $5.40 per visit for a comparable visibility scenario. If it is appropriate to compare these results across different individuals (i.e. , implicitly assuming users would also have a preservation value), the estimated preservation values for preserving visibility conditions at unique natural environments, such as the Grand Canyon, may be much greater than the user values for the same visibility conditions. Unfortunately, the study does not attempt to divide. the preservation benefit into an estimate of option price and an estimate of existence value. Thus, it is not directly comparable to either of the two studies discussed earlier in this section. Furthermore, the choice of two different payment vehicles may have introduced a starting point bias problem similar to that in the South Platte River study.

Thus, in summary, all past efforts at measuring nonuser values have met with only limited success. There has been controversy over whether option values were measured or it has not been possible to distinguish option price from other components of intrinsic values.

5,6 MEASURING OPTION VALUE: SURVEY DESIGN

As noted in Chapter 1, an important component of the Monongahela survey was the measurement of option price and user values. In addition, the question design permitted the implications of supply uncertainty for the estimates of option value to be examined. Since Chapter 3 described the sample survey design and Chapter 4 provided a summary of the features of the final sample, these will not be repeated here. Rather, this section will review the background information provided to each respondent and the form of the questions used to derive estimates of the option value associated with various water quality changes in the Monongahela survey.

As noted, the payment vehicle was described to be the taxes paid directly and the higher prices paid indirectly for imDroved water quality. This approach fol lows the format used by Mitchell and Carson [1981] with several importent additions. Each interviewer was trained to explain carefully the mechanisms that underl e the payment vehicles. The objective of these explanations was to ensure that respondents understood the nature of the payment vehicle and recognized that similar types of payments take place in practice as a result of government and private sector decisions. Each respondent was shown a map of the area highlighting the locations of recreation sites along the river. This map is reproduced as Figure 4-3. Before proceeding to the questions, the interviewer described the reasons why one might be interested in water quality for the Monongahela River. Using a value card (i.e. , Figure 4-6), actual use, potential future use, and existence values were each identified as separate reasons for interest in the river water quality. Each was acknowledged to be a potential motivation for valuing water quality in the Monongahela River. The value card was explained at the outset of the interview and then shown again to each sample respondent as the questions designed to separate option price, expected consumer surplus, and existence values were asked. Thus, the value card translated the theoretical relationships relating option value, user value, and existence value into a format that linked them to respondents' experiences.

There are at least two ways to ask questions designed to measure the option values associated with water quality. The first of these involves proposing to respondents counterfactual situations that describe, in hypothetical terms, the probabilities and levels of use of the resource with different specified water quality levels. Each respondent is asked to value these plans. A second approach relies on the interviewer's ability to explain to the respondent why he might value water quality at a site, identifying the relationships between those reasons and a benefits taxonomy that isolates option value. With this explanation, the individual is then asked to bid in a way that separates the individual components of the values.

These methods contrast with a third approach employed by Mitchell and Carson, where a classification of individuals (as users or nonusers) assisted in decomposing benefits. That is, their classification, together with the assumption that nonusers were always nonusers and therefore could not have user values, allowed the willingness-to-pay estimates from nonusers to be interpreted as indicative of the intrinsic benefits held by users.

In the absence of the assumption that individuals are comparable (except in the decision between use or nonuse), the first two approaches to partitioning the benefits of a water quality improvement face problems. The first one attempts to "second guess" plausible demand conditions in its specification of the probabilities and levels of use that might be associated with a water quality level. Such specifications may actually bear little resemblance to what an individual would select. Thus, this approach was not used in this analysis.

The second approach relies on individuals' ability to "divide the benefits pie" consistently. Clearly, the estimates in this study depend not only upon how well each individual understood the concepts on the value card, but also upon how well he was able to (1) use them in classifying the contributions made to overall option price by expected user benefits and option values and (2) separate existence values as a distinct motive for valuing water quality improvements.

The Survey questions elicited an option price--the individually willingness to pay for the water quality change due to actual and potential use of the river. Following this question, the interviewer asked each person what amount of the option price was associated with actual use. This response has been interpreted as an estimate of the individual's expected consumer surplus. thus, the difference between the reported option price and the value associated with use corresponds to this study's estimate of option value.

The questionnaire design allowed evaluation of two further issues in the measurement of option value: (1) the amount of the water quality change and (2) the mode of questioning. The design considered three levels of change in water quality as reproduced in the water quality ladder shown in Figure 4-5. The first question considered the willingness to pay to avoid having the water quality deteriorate from its current level, Level D, acceptable for boating, to Level E, at which no recreation activities would be possible. Individuals were also asked their willingness to Pay for improvements from Level D to Level C, acceptable for sport fishing, and improvements from Level C to Level B, acceptable for swimming. As noted in the previous chapter, the water quality levels were defined based on Resources for the Future's water quality index (see Mitchell and Carson [1981]).

The second asPect of the questionnaire design involved the mechanism use to elicit the willingness-to-pay response. To investigate the effects of different questioning methods, the sample was divided into approximately four equal parts, each using a different questioning method--two different iterative bidding 9ame procedures, a direct question procedure, and a procedure using a direct question with a payment card. Iterative bidding games, practiced in most early contingent valuation experiments (see Schulze, d'Arge, and Brookshire [1981] for a review), involve a sequential process in which an interviewer proposes a value (the starting point) to the respondent and asks Whether it would be acceptable as a bid for the conditions described in the question. Based on the response, the interviewer raises or lowers the bid by a fixed amount until there is no change in the bid with repetition of the process. Two subsets of the sample used bidding game procedures; the first used a $25 starting point and a $5 increment, and the second used a $125 starting point and a $10 increment.

The third procedure used to elicit individual willingness to pay was a direct question with no suggestion of an amount. In the last component of the sample, respondents were asked to look at a payment card (see Figure 4-7) arraying alternative dollar values and to select one or any other amount as their willingness to pay. This last procedure is comparable to the Mitchell-Carson [1981] approach, with one modification. The values on the card were not identified as the individual's current spending on specific public sector activities. This practice of anchoring the values was not used because it was felt it would create the possibility of biased responses.

Each subsequent question for user values, supply uncertainty, and existence values repeated the amount given for willingness to pay and then asked the respondent to indicate what portion of the reported willingness to pay is

Table 5-2. Summary of Willingness-to-Pay Questions by Type of Interview

Type of interview	Question format
Iterative bidding $25	To you (and your family), would it be worth $25 each year in higher taxes and prices for products that companies sell to keep the water quality in the Monongahela River from slipping back from Level D to Level E?
Iterative bidding $125	To you (and your family), would it be worth $125 each year in higher taxes and prices for products that companies sell to keep the water quality in the Monongahela River from slipping back from Level D to Level E?
Direct question	What 'is the most it is worth to you (and your family) on a yearly basis to keep the water quality in the Monongahela River from slipping back from Level D to Level E, where it is not even clean enough for boating?
Payment card	What is the most it is worth to you (and your family) on a yearly basis to keep the water quality in the Monongahela River from slipping back from Level D to Level E, where it is not even clean enough for boating?

Table 5-3. Summary of User, Supply Uncertainty, and Existence Value Questions

Type of response	Question format
User value	In answering the next question(s), keep in mind your actual and possible future use of the Monongahela. You told me in the last section that it was worth $(AMOUNT) to keep the water quality from slipping from Level D to Level E. How much of this amount was based on your actual use of the river?
Supply uncertainty	If the water pollution laws were relaxed to the point that the water quality would decrease to Level E and the area would be closed 1/4 of the weekends of the year for activities on or in the water but would remain open for activities near the water, how much would you change this (READ TOTAL $AMOUNT) to keep the area open all weekends for all activities?
Existence value	What is the most that you (and your family) would be willing to pay each year in the form of higher taxes and prices for the goods you buy for keeping the river at Level D where it is okay for boating, even if you would never use the river? Suppose the change could not be reversed for an even longer period of time than your lifetime. How much more than (READ AMOUNT FROM a.) would you (and your family) be willing to pay per year to keep the river at Level D, even if You would never use the river?

associated with each of the components Of value or complications to the choice process. Table 5-2 reports the form of the willingness-to-pay questions used for the case of Preventing deterioration from water quality Level D to Level E for each mode.

The questions used to measure the values associated with use, supply uncertainty, and existence values did not change with the type of interview and samples and are reported in Table 5-3. The examples correspond to the scenario used for the willingness-to-pay questions in Table 5-2. The responses to these questions form the basis for the results reported in the next section of this chapter.

5.7 SURVEY RESULTS--OPTION VALUE

The results for the empirical estimates of option value are divided into two parts. The first considers the conventional treatment of option value as a response to demand uncertainty. The second considers the sensitivity of these findings to changes. in the conditions of access to the Monongahela River by varying the proposed likelihood of being able to use the site.

5.7.1 Option Value--Demand Uncertainty

Table 5-4 presents a summary of the sample mean estimate of option value for each water quality change based on each of the four types of interview frameworks. The estimates for each water quality change are the increments to the reported willingness to pay to prevent the water quality from deteriorating to the level given as E. Thus, each respondent was asked if he would be willing to pay more than the amount recorded for avoiding a movement from D to E. When an affirmative answer was given, the interviewer proceeded with the increments from D to C and from C to B. Since some individuals were unwilling to pay for further improvements, the "no" responses to subsequent improvements were treated as zeros in constructing the means.

Analysis of the survey responses revealed that two definitions of "users" were possible. The first of these would classify individuals according to whether they reported a user value or indicated that they had used the river for recreation activities in the previous year. This definition is the focus of attention in this chapter and is designated as the "broad definition" of users. The second defines users as only those individuals who indicated that they had used the Monongahela sites. This narrow definition focuses on a subset of the users under the first definition. Appendix C reports a sample of the results under the narrow definition.

The analysis performed for this study has considered both the sample means and linear regression models to summarize the survey results. Table 5-4 provides estimates for option value for different levels of water quality change according to the survey instrument used. Informal review of these estimates seems to indicate that the question format influences the magnitude of the estimates. Following the practices described in Chapter 4, these estimates are based on a restricted sample: Observations identified as either

Table 5-4. Estimated Option Values for Water Quality Change: Effects of Instrument and Type of Respondent--Protest Bids and Outliers Excluded

Change in water quality	Type of respondent					
	User [a]			Nonuser		
	$\bar{x}$	s	n	$\bar{x}$	s	n
1. Iterative Bidding Framework, Starting Point = $25						
D to E (avoid)	20.79	16.61	19	29.74	36.69	39
D to C	14.74	13.99	19	14.49	15.17	39
C to B	6.84	10.70	19	7.18	11.63	39
D to B	21.58	22.05	19	21.67	24.04	39
2. Iterative Bidding Framework, Starting Point = $125						
D to E (avoid)	58.44	66.60	16	38.75	51.32	32
D to C	37.81	49.13	16	26.25	45.38	32
C to B	13.13	32.65	16	11.56	33.06	32
D to B	50.94	71.44	16	40.47	69.02	32
3. Direct Question Framework						
D to E (avoid)	25.59	43.04	17	14.18	27.12	34
D to C	10.12	24.45	17	10.82	21.56	34
C to B	10.18	24.49	17	8.47	21.87	34
D to B	21.77	48.57	17	20.32	41.45	34
4. Payment Card						
D to E (avoid)	27.06	33.12	17	52.97	76.31	37
D to C	14.41	20.38	17	21.89	33.80	37
C to B	3.26	8.28	17	7.70	19.99	37
D to B	20.00	25.06	17	29.87	47.54	37

[a]These results are based on the broad definition of users.

protest bids or as rejecting or misunderstanding the contingent valuation experiment were deleted. The latter were initially identified as outlying observations using regression diagnostics (see Belsley, Kuh, and Welsch [1980]). This statistical identification was followed by an evaluation of the features of the observations that made them distinct (see Table 4-8 and Section 4.5 for further discussion). To consider this issue, as well as the potential effects of being a user of the river, several null hypotheses have been chosen for testing using a student t-test for the difference of sample means. Equation (5. 14) below provides the test-statistic used for these tests:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1 - 1) S_1^2 + (n_2 - 1) S_2^2}{(n_1 + n_2 - 2)} \cdot \frac{n_1 + n_2}{n_1 \cdot n_2}}} \quad . \quad (5.14)$$

where

$\bar{X}_i$ = sample mean for the ith grouping of individuals (e.g. , users, nonusers, respondents with a particular question format, etc.),

S_i = sample standard deviation for ith grouping of individuals

n_i = sample size for the ith grouping of individuals.

All combinations of questioning format for each type of improvement in water quality were compared for users and nonusers. Overall, there were only a few cases where the estimated means were significantly different. As a rule these cases were associated with comparisons of the iterative bidding framework under the two starting points. Thus, there is some evidence of starting point bias with this approach to soliciting an individual's valuation of water quality. Indeed, these results for starting point bias would be strengthened if the observations that were deleted as invalid (from the diagnostic anal ysis) were Included in the sample. In several cases it was not possible to distinguish the effect of the higher starting point (i. e., $125) as an explanation of the observation's role as an outlier from another characteristic of the survey respondent involved (see Chapter 4). Table 5-5 summarizes the cases where statistically significant differences in the mean values for option value were found.

Table 5-5. Student t-Test Results for Question Format[a]

Means compared	t-Ratios User	t-Ratios Nonuser
Direct question vs. iterative bidding with $125 starting point D to C	-2.069	-2.452
Iterative bidding with $25 starting point vs. iterative bidding with $125 starting point D to E (avoid)	-2.384	--
Iterative bidding with $25 starting point vs. iterative bidding with $125 starting point D to C	-1.960	--
Direct question vs. iterative bidding with $125 starting point D to E	--	-2.035
Direct question vs. iterative bidding with $125 starting point D to B	--	-2.758

[a]This table reports only the cases where statistically significant differences in the means were found at the 0.05 significance level.

The responses of users and nonusers were also compared for each type of question and level of water quality change. Based on observation of values in Table 5-4, none of these cases indicated a significant difference in the means. Thus, despite the appearance of rather large differences for a few cases (e. g. , payment card with Level D to Level E), the estimated means are not significantly different.

Table 5-6 reports the findings of a sample of the linear regression models considered in attempting to explain the determinants of the option value estimates using the survey respondents' economic and demographic characteristics. These models should not be interpreted as estimates of a behavioral model. Rather, they were estimated as summaries of the survey data in an attempt to

Table 5-6. Regression Results for Option Value Estimates--Protest Bids and Outliers Excluded[a]

	Water quality changes			
Independent variables	D to E (avoid)	D to C	C to B	D to B
Intercept	-17.014	-7.170	10.149	3.635
	(-0.540)	(-0.380)	(0.692)	(0.126)
Sex (1 if male)	4.121	-0.133	-2.332	-3.301
	(0.484)	(-0.026)	(0.589)	(-0.424)
Age	-0.411	-0.216	-0.131	-0.350
	(-1.637)	(-1.435)	(-1.120)	(-1.523)
User (1 if user)	-18.454	-10.609	-4.518	-15.761
	(-2.097)	(-2.011)	(-1.104)	(-1.958)
Education	4.830	2.084	-0.167	1.986
	(2.052)	(1.477)	(-0.152)	(0.922)
Income	0.0005	0.00005	0.0002	0.0002
	(1.384)	(0.210)	(1.035)	(0.532)
Direct question	-26.128	-7.472	3.335	-3.817
	(-2.356)	(-1.124)	(0.646)	(-0.376)
Iterative bidding game ($25)	-12.681	-0.274	1.773	0.339
	(1.188)	(-0.043)	(0.357)	(0.035)
Iterative bidding game ($125)	14.638	20.601	7.575	29.627
	(1.245)	(2.923)	(1.385)	(2.754)
Willing to pay cost of water pollution (1 if very much or somewhat)	16.069	16.611	4.510	23.229
	(1.842)	(3.176)	(1.111)	(2.910)
R^2	0.212	0.208	0.053	0.170
F	4.34	4.23	0.90	3.30
Degrees of freedom	155	155	155	155

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

improve the ability todescribe the attributes of individual respondents that seem to influence the estimates of option value. Thus, while these results have limited explanatory power as measured by the R* of each equation, they do provide somewhat different insights into the role of the type of respondent than those offered by the analysis of sample means. The independent variables in the model included qualitative variables for sex, question format (with the payment card as the omitted questioning mode), user, and the individualism expressed attitude foward paying for water quality improvements. The last of these was coded as a 1 if the individual "strongly" or "somewhat" considered himself a person willing to pay the cost required to control water pollution. Otherwise, the variable was coded as zero (i. e., for individuals who had little or no such feelings orhad no opinion on the matter).*

After the survey respondents' characteristics were controlled, users seemed to have lower oPtion values than nonusers. No differences were found using tests based on sample means. Since the tests for the equality of means did not control for the respondents' characteristics, the difference in the two conclusions is not surprising. The regression results add further support to the conclusion for a starting point bias. Two of the four models in Table 5-6 indicate that the qualitative variable -identifying the respondents who received the iterative bidding questionnaire with a $125 starting point was significantly different from zero. This implies that these responses are significantly different than those received using the payment card. The two most consistent determinants of the option value results in these models were the qualitative variables for Serand for the individual's willingness to pay the costs required for water pollution control.

Overall, these results indicate that it is possible to estimate option value for water quality changes. In general, the estimates are significantly different from zero. The effects of payment vehicle suggest that there appears to be a starting point bias with several estimates of option value for specific water quality changes. Morever, with the ability to control for respondents' characteristics, the iterative bidding approach with a $125 starting point was found to increase option value estimates over the responses made using a payment card.

The results were not especially successful in isolating the effects of other individual characteristics on the option value estimates. Only the variable indicating the individual's attitude toward paying for water pollution control was a consistent determinant of the option value estimates for the water quality changes.

These estimates are all based on the assumption that access to the site is quaranteed. Accordingly, the implications of supply uncertainty for the respondents' option prices are considered next.

5.7.2 Option Value--Supply Uncertainty

Because the theoretical analysis of the sign of option value and the results in Smith [1983] suggest that individuals' assumptions regarding their

*A more detailed description of these variables is provided in Chapter 4.

ability to gain access to the site--i. e., the degree of perceived supply uncertainty--may be important to the magnitude of option value, several questions were incorporated to attempt to measure its effects on individual's responses. Table 5-3 reported the question used to gauge the effects of supply uncertainty. Three variants of the question were posed, each of which referred to the amount an individual would be willing to pay to prevent water quality in the Monongahela River from deteriorating from boatable to unusable. supply uncertainty was introduced by suggesting that the water quality deterioration would take place and that it would reduce the probability of having access to the river's recreation sites. The first question postulated that activities on or in the water would be precluded for one-fourth of the weekends in the year. The respondent was informed that it would not be known in advance which weekends would be involved. The fraction of weekends during which the sites were closed was progressively increased through two more steps to one-half and three-fourths of the weekends. Table 5-7 reports the estimated mean adjustments to the original bids made by users and nonusers. That is, each respondent was reminded of his bid to prevent water quality from deteriorating from Level B to Level E and then asked how much this amount would be altered to reflect the supply uncertainty.

These responses indicate that supply uncertainty clearly affects the option prices bid by users. The means for users under each of the three conditions of supply uncertainty are significantly different from zero at the 5-percent level. These results suggest that the option price would be reduced if the water quality level led to uncertain availability of the site. The mean adjustments to the option prices reported by nonusers were not significantly different from zero.

Table 5-7. Effects of Supply Uncertainty on Option Price[a]

Condition of water quality change	Summary statistics	User[b]	Nonuser[b]
Avoid a certain change B to E	$\bar{X}$	114.710	61.817
	s	112.501	85.40
	n	69	142
Experience water quality change to E, lose 1/4 weekends	$\bar{X}$	-14.552	-6.354
	s	52.328	39.891
	n	67	96
Experience water quality change to E, lose 1/2 weekends	$\bar{X}$	-22.537	-5.833
	s	58.331	43.996
	n	67	96
Experience water quality change to E, lose 3/4 weekends	$\bar{X}$	-26.866	-6.042
	s	68.500	46.220
	n	67	96

[a]These results are based on a sample that deletes protest bids and the observations identified as inconsistent with the contingent valuation framework.

[b]The difference in the number of observations between the certain case and the uncertain cases reflects missing observations.

Table 5-8. Student t-Tests for the Effects of Supply Uncertainty for Users

Means	t-Ratio
Water quality reduces access for:	
(1) 1/4 weekends vs. 1/2 weekends	0.834
(2) 1/4 weekends vs. 3/4 weekends	1.169
(3) 1/2 weekends vs. 3/4 weekends	0.394

Table 5-8 reports the results for tests of the differences in the mean adjustments with progressive increases in the degree of supply uncertainty. The results suggest that the mean adjustments are not significantly different with increases in the uncertainty in the availability of the site.

In summary, these empirical findings confirms the theoretical arguments developed earlier. Supply uncertainty can be expected to affect option value. Avoiding supply certainty and the associated risk is further basis for a positive option value.

5.8 EXISTENCE VALUE ESTIMATES

Since they were first introduced by Krutilla [1967] , existence values have been given little attention within conventional models of consumer behavior. * The recent experimental findings of Schulze et al. [1981], discussed earlier in this chapter, have changed this perspective. Their estimates of preservation values for the Grand Canyon's visibility conditions indicate that the nonuser values for this unique natural environment are likely to be several times the magnitude of the user-associated benefits. While ~t is not unambiguously clear, preservation values can be expected to include option value, existence value, and, perhaps, bequest values. Each of these motivations for desiring the services of a unique natural environment was identified by Krutilla as values that would not necessarily be reflected in the private market transactions for the services of such resources.

As a result of these empirical findings, the attention given to modeling and measuring existence values has increased. Freeman's [1981] recent notes on the problems associated with defining and measuring existence values indicate at least two interpretations of an individual's reasons for valuing the existence of a resource. In the first note, Freeman designates a stewardship value (or motive), where the level of use of a resource affects the value derived. In this case, one's existence value would be reduced if the resource

*One notable exception is Miller and Menz's [1979] model for describing efficient allocation decisions involving wildlife preservation. These authors introduce species stock terms into individuals' utility functions as a source of value, without requiring that these values arise from consumptive uses. However, the authors do not explicitly identify the rationale for their specification in terms of existence value.

were not properly managed. Freeman's second proposed reason for existence value stems from a form of vicarious consumption. An individual derives benefit from the knowledge that other individuals can use a resource.

Freeman's analysis does not develop either of these frameworks in detail. They were suggested only as prospective explanations for values due to the existence of a resource and can be interpreted as defining different forms of consumption. Thus, they do not provide direct insight into how existence values might be measured. However, Freeman does suggest that attempts to measure existence value should carefully identify the likelihood of future use of the site and elicit an individual's user and nonuser values. In effect, he proposes that questions call for the sum of option price and existence value.

The design of the existence value questions for this survey attempted to use these insights. The sources of site valuation (on the value card used in the interviews) were separated into direct use, potential use, and existence motives. After reviewing these motivations, the interviewer asked each respondent how much he would be willing to pay to prevent the deterioration of water quality from boatable conditions to an unusable state even though he never would plan to use the river. Responses to these questions were regarded as tentative estimates of existence values. The situation is a difficult one for the respondent to conceptualize. Water quality is to remain at a boatable level, but the individual nonetheless will not use the river.

Table 5-9 presents these results for users and nonusers with the sample restricted to exclude protest bids and observations judged to be inconsistent with the contingent valuation framework. Both estimates are significantly different from zero. Users do exhibit significantly different estimated existence values from nonusers at the 5-percent level. These values are quite comparable to the estimates for the option price (aggregated over question mode), as reported in Table 4-9 for avoiding the loss of use of the river. Indeed, there is not a significant difference between the means for either users or nonusers. This finding, together with the fact that many respondents repeated their option price bids for the existence value question, suggests that these results should be interpreted with caution. Until the theoretical issues associated with describing the relationship between user and existence values is resolved, it cannot be concluded that these estimates represent independent sources of value for a water quality improvement.

Table 5-9. Estimated Existence Values

	User	Nonuser
Mean ($\bar{X}$)	65.985	42.115
Standard deviation(s)	92.824	64.023
n	66	139

5.9 SUMMARY

This chapter has reviewed the theory underlying the definition of option value, summarized the results of past efforts to measure option and other nonuser values, and presented the results of the Monongahela River survey that relate to nonuser values.

The findings provide clear support for a positive, statistically significant, and substantial option value for water quality improvements for the Monongahela River. The estimated option values for loss of the use of the area in its current condition (i.e. , providing boating recreation activities) range from approximately $21 to $58 for users (and $14 to $53 for nonusers). The option price for users ranges from approximately $27 to $95. Thus, option value is a substantial fraction of the option price of users and generally exceeds their use values for a change in water quality. The Monongahela River is not a unique recreation site. Thus, these estimates may well require reconsideration of the conventional assumption that option value is small in comparison to use value for natural environments without unique attributes. Of course, it should also be acknowledged that the available estimates of option value are quite limited. Most can be criticized for problems in the research design, including possible flaws in the survey. The design of the Monongahela River study places heavy reliance on the use of a schematic classification of the sources of an individual's valuation of the river (i .e. , the value card) in eliciting a division of user and nonuse benefits. Because this is the first application of this device, it was not possible to evaluate its effectiveness.

Users appear to have a somewhat lower option value than nonusers for most levels of change in water quality. For the most part, the respondents' socioeconomic characteristics were not useful in explaining the variation in estimated option values.

The limited analysis of the role of supply uncertainty for measures of option value clearly suggests it is an important influence on users' option price (and therefore on the derived option value). Assurance of supply is quite important to our positive estimates for option value.

Finally, this survey provided the ability to estimate existence values. While the findings suggest that these values are positive and statistically significant, prudence requires they be interpreted cautiously. It is not clear that respondents understood the distinction sought. Many bid the same amounts as their earlier option prices for a comparable change in water quality.

CHAPTER 6

CONTINGENT RANKING DESIGN AND RESULTS: OPTION PRICES*

6.1 INTRODUCTION

The purpose of this chapter is to report a set of water quality benefit estimates based on an analysis of the Monongahela survey respondents' rankings of four hypothetical combinations of water quality levels and amounts paid in the form of higher taxes and prices. The use of data including individuals' rankings of goods or services described in terms of the features of each of a set of possible alternatives together with an extension of the McFadden [1974] random utility model was first proposed by Beggs, Cardell, and Hausman [1981] as a method for measuring the potential demand for new goods. Rae [1981a, 1981b] has subsequently used this approach as' an alternative means of estimating individuals' valuation of air quality improvements. The implicit assumption of the contingent ranking approach is that individuals are more likely to be capable of ordering hypothetical combinations of environmental amenities and fees than to directly reveal their willingness to pay for any specific change in these amenities. Unfortunately, past studies have tended to adopt only one or the other of these two approaches, and there has been little basis for comparing their respective estimates. As a result, the survey instrument for the Monongahela study was designed explicitly to include the use of contingent ranking as a method for measuring individuals' valuation of water quality improvements. All survey respondents were asked to rank four hypothetical combinations of water quality and payments to permit a comparison of contingent valuation and contingent ranking methods within the context of a common application.

To understand the economic basis for modeling consumer behavior using contingent rankings, the random utility model--widely applied to model consumer behavior that involves discrete choices--must first be considered. Section 6.2 provides some of this background by describing the features of the random utility model, and Section 6.3 discusses two possible methods for implementing the model. The first, an adaptation of the conditional logit model, can be derived under the assumption that the errors associated with the random utility function are additive and follow an extreme value distribution (i.e. , the Weibull distribution). The second, a normal counterpart to the

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*Special acknowledgment is due Donald Waldman of the Department of Economics, University of North Carolina at Chapel Hill, who helped develop the maximum likelihood program for ordered logit analysis and provided a general program for estimating the Keener-Waldman ordered normal estimates. He also assisted in the estimation and discussed several aspects of these models with the authors.

ordered logit was recently developed by Keener and Waldman [1981], who used numerical procedures to approximate the likelihood function associated with a random utility function having additive normal errors. With this background, Section 6.4 summarizes the results of Rae's survey applications of the contingent ranking approach to benefit estimation for visibility change; Section 6.5 discusses the question used for contingent ranking and the empirical estimates of random utility models; and Section 6.6 considers some of the theoretical issues associated with Rae's proposed approach for benefit estimation with the model and reports the results derived by applying it directly with the Monongahela survey data. Finally, Section 6.7 summarizes the chapter and proposes an alternative application of the random utility model.

6.2 CONSUMER BEHAVIOR AND THE CONTINGENT RANKING FRAMEWORK

The conventional economic description of consumer behavior generally maintains that each individual consumes some amount of every good or service that enters his utility function. The objective of these models is to describe the choices individuals make for marginal increments to their consumption levels. That is, individuals are usually portrayed as adding to previous consumption of goods or services from which they derive utility. * Of course, many consumer choices involve major purchases. In the purchase of an automobile or a house, the selection of an occupation, or the choice of an appliance, the consumer's decisions all require discrete choices. In these cases, the commodity often is durable and provides a stream of services over some time period or involves some commitment of the individual's time. Thus, the assumption of continuous incremental adjustment in the levels of consumption of each good or service that is implied in the conventional model of consumer behavior is not plausible for describing individuals' choices when they involve discrete selections.

Several types of modifications to conventional models have been proposed to make them more amenable to explaining such discrete choice problems. One involves an extension of the time horizon in the conventional model of consumer behavior. For example, on any particular day a commuter will select a travel mode to reach his job. Viewed on a daily basis, modal choice is discrete since fractions of the available travel modes cannot, as a rule, be consumed in a single trip to the workplace. However, over the course of a month or a year, the individual may well select a varied menu of transport modes. Thus, with this adaptation of lengthening the time horizon, the conventional model of consumer behavior may be more relevant to explaining these decisions.

A second proposed adaptation for dealing with discrete choices involves modeling consumer decisions as service flows rather than as the choice of any particular asset. For example, an individual purchases an auto for transportation services. These service decisions may be more amenable, under this interpretation of conventional theory, to modeling than the discrete choices of

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*Conventional models of consumer behavior assume positive levels of consumption of all goods and services to avoid dealing with corner solutions.

durable goods themselves. As a practical matter, however, most of the modifications to the conventional theory have enjoyed limited success. Information on the consumption rates for the services of durables is virtually nonexistent. Forecasts of the rates of use of travel modes based on aggregate information over long time spans cannot take account of the specific constraints facing individuals in making these decisions and, as a result, may be inadequate for many problems.

The random utility model has been proposed as one approach for dealing with discrete consumer choices. It generally replaces the assumption of a common behavioral objective function across individuals with the assumption of a distribution of objective fUnCtiOn S. Attention is shifted from the intensive choice margin and the associated incremental analysis to individual decision-making at an extensive margin with discrete selections. As a result, random utility models are often quite simple in their description of the choice process. Individuals are assumed to have utility functions affected by (1) the objects of choice and their features and (2) the characteristics of the individuals making the decisions. The analyst is assumed to be capable of observing the distribution of individuals and their respective choices but does so without complete information. Thus, the observed behavior is assumed to be described as a trial--the drawing of one individual from a population; the recording of his attributes, the alternatives available, and their features; and the making of a choice. Because there is a distribution of individuals, the model describes the choice process using a conditional probability. Each alternative has some probability of being selected based on its characteristics, the other alternatives available and their features, and the attributes of the individual selected. Behavior is described by modeling these probabilities.

The random utility function provides the vehicle for modeling these conditional probabilities. In a random utility framework, the individual is assumed to select alternatives that provide the highest utility level. Thus, if Equation (6.1) describes a random utility function, then individual j's probability of selecting alternative k, given j's attributes, z., and in the presence of the set of alternatives defined by A, is defined by' the probability that j's utility of k will exceed the utility of all other alternatives, as given in Equation (6.2) below:

$$U(a, z) = V(a, z) + \varepsilon(a, z) \, , \tag{6.1}$$

where

$U(a, z)$ = utility provided by an alternative's vector of characteristics, a;

z = attributes of the individual;

$V(a, z)$ = nonstochastic component of utility, describing what constitutes representative tastes in the population; and

$\varepsilon(a, z)$ = stochastic effect reflecting the nondeterministic effects of taste on decisionmaking for an individual with attributes, z, facing an alternative with characteristics, a.

$$\text{Prob}\ [a_k\, z_j,\ A] = \text{Prob}\ [U_k > U_i \text{ for all } i \# k] \ \square$$

$$\text{Prob}\ [V(a_k, z_j) - V(a_i, z_j) > \varepsilon(a_i, z_{,}\ \varepsilon(a_k, z_j), \text{ for all } i \# k] \qquad (6.2)$$

By making distributional assumptions to characterize the ε's, the probability statement in Equation (6.2) can be defined in terms of the characteristics of the alternatives and the features of the individual. For example, assuming that the ε's are independently, identically distributed with the Weibull distribution* allows the probability to be expressed as a logistic, as in Equation (6.3):

$$\text{Prob}[U_k > U_i \text{ for } i \# k] = \frac{\exp(V_k)}{\exp(Vk) + \exp(V_i)} \qquad (6.3)$$

Before the relationship of random utility functions to contingent ranking is explained, several observations on the nature of these functions should be noted. The description in Equation (6.1) is a conventional treatment (see McFadden [1974] or [1981]) that is completely general. In this general description there is no explicit treatment of the constraints to choice, such as an individual's income or market prices. To make these constraints clearer, it is completely consistent with the random utility model to view V(I) as the result of a constrained optimization process. Within such a framework, $V(\cdot)$ would be an indirect utility function, reflecting an individual's attributes, the characteristics of the choice alternatives (to the extent they are not reflected in market prices), the individual's income, and the prices of the alternatives available on organized markets. †

Thus, a random utility function framework does not imply that the conventional economic view of the consumer behavior be ignored. Indeed, as McFadden [1981] has suggested, $V(\cdot)$ can be regarded as an indirect utility function, even in applications where it has been specified as linear in its parameters. This interpretation is possible because any continuous function can be approximated to any desired degree of accuracy with a linear specification. The requirement that $V(\cdot)$ be homogeneous of degree zero in income and prices can be met by requiring that the variables in the linear approximation (in parameters) be homogeneous of degree zero. (This requirement is necessary for consumers to be free from "money illusion" and to respond only to changes in relative prices and income.)

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*The distribution function for the Weibull distribution is:

$$\text{Prob}(Z \leq t) = \exp(\exp\ (-(t-a)/O))$$

The ordered logit is derived for a standardized form with $\sigma = 0$ and $\theta = 1$. This implies that variance of the errors will be 1.6449. See Chapter 20 of Johnson and Kotz [1970] for more details.

†This description admits the possibility of a model comparable to the hedonic framework used in modeling property values (see Rosen [1974]) or, more recently, adapted to a travel cost recreation demand framework by Brown and Mendelssohn [1980]

Alternatively, it is possible to assume that the indirect utility function is separable in all commodity prices but the ones of direct interest. Moreover, in principle, these prices can be replaced by a price index that can be assumed to normalize the incomes and the prices of goods and services of interest. However, it should also be acknowledged that this approach imposes quite restrictive assumptions on the structure of individual preferences. * The primary conclusion to be drawn from these general observations is that conventional neoclassical models of consumer behavior can be used as an integral part of random utility models when the utility functions are interpreted as indirect functions describing the outcomes of households' optimizing decisions.

A second feature of the models used in the random utility framework stems from the assumption of the independence of irrelevant alternatives. This assumption is important to the structure of any model in the framework because it implies that the odds of one alternative being chosen over a second alternative are not affected by any other alternatives. McFadden [1974] has conveniently summarized the implications of this assumption in discussing the limitations to the random utility model:

> The primary limitation of the model is that the independence of irrelevant alternatives axiom is implausible for alternative sets containing choices that are close substitutes. . . . application of the model should be limited to situations where the alternatives can plausibly be assumed to be distinct and weighed independently in the eyes of each decisionmaker. (McFadden [1974], p. 113)

With this background on the random utility model and its relationship to the conventional model of consumer behavior, it is possible to consider the contingent ranking methodology. The contingent ranking methodology maintains that individuals' valuation of environmental amenities, such as visibility or improved water quality, can be described within a random utility framework. Thus, an approach to estimating individuals' values for changes in these amenities could be developed by estimating the deterministic component of the random utility function--i.e. , the $V(\cdot)$ in Equation (6.1). The process of collecting the information necessary to derive these estimates involves presenting individuals with a set of alternatives. Each alternative describes a specific state of the world in that it characterizes the features of the environmental resource and the cost to the individual of having access to the resource under the specified conditions. Individuals are then asked to order the alternatives from most to least preferred. If the determinants of $V(\cdot)$ are known and it can be approximated using models that are linear in parameters, the ranking of the alternatives provides sufficient information to estimate (relative to a scale factor) the parameters of these models,

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*Applications of these principles have been used by Hausman and Wise [1978] . The restrictive assumptions required are discussed In detail by Blackorby, Primont, and Russell [1978]. Based on their analysis (especially in Chapter 5), this approach--used by Hausman and Wise, for example--requires separability in commodity prices (called indirect separability by Blackorby, Primont, and Russell) and additive price aggregation. These assumptions imply that the utility function will exhibit homothetic separability.

The contingent ranking methodology provides an operational basis for benefit measurement. However, several factors should be considered in using this methodology to estimate benefits of environmental amenities. Consistent benefit measurement requires recognition of the constraints on individual choice. Thus, to define compensating variation or compensating surplus benefit measures, $V(\cdot)$ must be considered an indirect utility function. Moreover, when individuals are asked to rank alternatives that involve levels of an environmental amenity and a fee, the role of the fee must be considered within an optimizing mode! of consumer behavior. That is, the selection of the payment vehicle may have an important effect on the specification of the random utility function. For example, if the fee included in each alternative is a user charge associated with gaining access to the resource whose features are also being described, the fee would be treated as a price per unit of use of the resource. Therefore, it would enter the indirect utility function in a format comparable to any other price. By contrast, if the fee is described as an annual payment, regardless of how much the resource is used, it would be expected to enter as an adjustment of income rather than as a price per unit of use of the resource. The indirect utility function can be expected to be homogeneous of degree zero in income and prices. While assumptions that can simplify the form of the function and the number of distinct prices need to be considered, they impose significant restrictions on the types of features of demand relationships between the commodities consumed by the individual. These issues are discussed in more detail below.

The required assumption of independence of irrelevant alternatives limits the generality of the contingent ranking methodology for benefit estimation. The definition of the alternatives presented to individuals in a contingent ranking is largely arbitrary and is constructed to ensure a distinct ranking of the combinations presented. Indeed, the literature to date has not explicitly considered the issues associated with experimental design in selecting the alternatives used. While this problem does not arise in application of the model to alternatives defined by what is available in the real world, it may well be an important consideration when the alternatives are specified to represent feasible alternatives or defined to provide the "best" estimates of an individual's compensating surplus for a change in an environmental amenity.

The framework used for benefit estimation (and described later in this chapter) implies that the level of environmental quality and proposed fee are subject to continuous tradeoffs as each varies over predefine ranges. This presumption is quite different from those cases for which McFadden [1981] argued the random utility function is best suited. Thus, even a brief consideration of the economic theory and assumptions underlying conventional formulations of the random utility model indicates there may be problems with its use in the contingent ranking methodology as a procedure for benefit estimation. Equally important, economic theory offers some guidance in selecting the most appropriate specification in empirical applications of the model.

6.3 ESTIMATION OF RANDOM UTILITY MODELS WITH ORDERED ALTERNATIVES

The random utility model can be estimated using the information provided in contingent rankings with a maximum likelihood estimator. That is, once the additive error associated with each individual's utility function is assumed to follow a probability distribution, the decision rule given in Equation (6.2) describing how each individual orders the available alternatives provides the information necessary to describe the probability of a specific ordering of alternatives. Of course, for some assumptions concerning the probability distribution for $\varepsilon(\cdot)$, the form is simpler than it is for others. Nonetheless, in principle, any assumed probability distribution provides the basis for describing this probability, which is the basic ingredient in the definition of the likelihood function (i.e. , the joint probability of observing all the orderings given in a specific sample as a function of the parameters of the utility function). The criteria of maximum likelihood estimation can then be used to derive estimates of the parameters (relative to a scale factor) of the deterministic portion of the utility function.

The discussions to this point as well as the existing applications of the contingent ranking methodology have assumed, for analytical convenience, that the errors follow a Weibull distribution in deriving an ordered logit estimator for the parameters of the function specified to represent (or to approximate) $V(\cdot)$. Because the logic underlying this derivation has been outlined in Beggs, Cardell, and Hausman [1981], some features of the estimator are simply highlighted here as they relate to the logit model applied to problems involving discrete choices (as given in Equation (6.3)) versus those based on an ordering of several alternatives.

A closed form expression for the probability of an ordering of the alternatives can be derived using the properties of the Weibull distribution. More specifically, the conditional probability $Prob(U_j \le t \mid U_j > U_k$, for $j \ne k)$ differs only in its location parameter from the unconditional distribution, as illustrated for this two-alternative case in Equations (6.4a) and (6.4b):

$$Prob(U_j \le t) = \exp(-\exp(-(U_j - V_j))), \quad \text{unconditional distribution.} \tag{6.4a}$$

$$Prob(U_j \le t \mid U_j > U_k \text{ for } j \ne k) = \exp(-\exp(-(U - \log(e^{V_j} + e^{V_k})))). \tag{6.4b}$$

Beggs, Cardell, and Hausman [1981] have outlined how this result can be used to derive the probability of an ordering of alternatives as given in Equation (6.5):

$$Prob(U_1 > U_2 > U_3 > \ldots > U_H) = \prod_{k=1}^{H} \left[\frac{e^{V_k}}{\sum_{i=k}^{H} e^{V_i}} \right], \tag{6.5}$$

where

H = the number of alternatives.

Equation (6.5) describes for any individual the probability of an observed ordering of alternatives. Under the assumption that each individual's decisions on ordering the alternatives are independent of all others, the likelihood function can be defined for a sample of T individuals as:

$$L = \prod_{j=1}^{T} \prod_{k=1}^{H} \left[\frac{e^{V_{jk}}}{\sum_{l=k}^{H} e^{V_{jl}}} \right] \tag{6.6}$$

By specifying the determinants of V_{jk}, the likelihood function, L, can be expressed in terms of unknown, estimatable parameters. Thus, for example, if V_{jk} is described by Equation (6.7), the likelihood function can, for a given sample, be expressed in terms of the unobservable parameters, β:*

$$V_{jk} = Z_{jk}\,\beta \,, \tag{6.7}$$

where

Z_{jk} = vector (lx K) describing the individual's characteristics, attributes of alternatives being ranked, and other variables as detailed by economic model used to describe behavioral choice

β = vector Kxl of parameters to be estimated.

Substituting Equation (6.7) into Equation (6.6) and taking the logarithm yields the log-likelihood function for the ordered logit estimator.† Maximum likelihood estimation involves solving this function for the value of β, which maximizes the log-likelihood function. In most cases, this solution involves numerical optimization procedures. Our analysis of the logit estimator used the Davidon, Fletcher, and Powell [1963] (DFP) algorithm with numerical partial derivations.

The second estimator for use with information from contingent ranking was developed by Keener and Waldman [1981] and follows the same behavioral model. In the Keener and Waldman framework, the errors associated with the

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*See Section 6.3, above, for a description of the relationship between a general form for the Weibull and the standardized form that underlies the Beggs, Cardell, and Hausman [1981] derivations.

†This estimator is actually the same method proposed by Cox [1972] for dealing with duration problems. That is, Cox proposed a conditional likelihood model based on ordering the variable of interest. His framework maintains a proportional hazard formulation of the problem. The two likelihood functions will be identical in the absence of ties (i.e. , Cox's analysis allows for ties in the ordering of the dependent variable, while the ranked logit does not).

random utility function were assumed to follow independent normal distributions. The probability of an ordering of alternatives is described by the multi variate, normal cumulative distribution function evaluated at $Z_{r(\ell+1)}\beta - Z_{r(\ell)}\beta$, $\ell = 1, 2, \ldots, H-1$, where r(n) is the index of the component of the vector of utilities for a given individual with rank ℓ. In general, the solution to the likelihood function for the normal distribution would pose a difficult numerical integration problem. However, Keener and Waldman observe that the error covariance matrix is tridiagonal and propose a computationally tractable method of numerically evaluating the probabilities composing the likelihood function. Thus, the likelihood function for the ranked normal estimator is derived by numerically integrating these functions to obtain the probabilities of the orderings provided by each sample respondent. Numerical maximization of this function yields the Keener -Waldman estimates. The DFP algorithm was also used to maximize the likelihood function associated with this estimator. Because ranked logit is globably concave, most experience with the method indicates it converges rapidly. Thus, estimation with the ordered logit framework is comparatively inexpensive. By contrast, as the above description implies, the maximum likelihood estimator based on the assumption of normality can be an expensive approach. Consequently, the ranked logit method has been used here to examine a wide array of alternative specifications for the deterministic component of the random utility function and the ranked normal for the subset of those models that were judged to be the “best.”

6.4 PAST APPLICATIONS OF CONTINGENT RANKING

The use of contingent ranking procedures for benefit estimation with environmental amenities has been a recent development. The applications have been exclusively conducted by Douglas Rae of Charles River Associates and have focused on valuing visibility changes. Our review considers two unpublished reports (Rae [1981a, 1981 b]) describing applications of the methodology.* Because the studies were largely motivated by concern over the benefits associated with defining alternative visibility standards for Class I areas (as mandated under the 1977 Amendments to the Clean Air Act), the surveys have been conducted at fairly unique recreational areas--the Mesa Verde National Park and the Great Smoky National Park.

The experimental design used in the two surveys was quite similar. In each case, a sample of users of a park was asked to rank a set of alternatives. The set was composed of two types of alternatives. One type specified combinations of conditions for the park where the survey was being conducted. These conditions included different visibility conditions (using photographs to display an integral vista within the park), a recreational quality measure (generally measured by waiting time at a key landmark or availability of activities at a park service center), and a per vehicle entry fee. The second type of alternative included other sites. The reports are not clear as to

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*Since the draft version of this report was prepared, a third application (Rae [1982]) to visibility changes in Cincinnati has been undertaken, but is not considered in this review. Future references will use the author’s name [Rae] and will refer to these 1981 reports.

whether comparable attributes were reported on the cards used to describe these other sites or whether the evaluation of the characteristics of these sites was left to the respondents. Table 6-1 describes the features and selected results for each of these studies.

Each respondent was asked to provide two rankings. The information detailed in Table 6-1 is based on the rankings for deterministic conditions. That is, in the cases shown in Table 6-1, the alternatives were explained as having constant visibility at the level prescribed. In addition to these rankings, individuals in each study were asked about alternatives that included deterministic and probabilistic descriptions of visibility conditions (i.e. , three probabilistic cases and four with constant visibility prescribed). The probabilistic cases specified the percentage of summer daylight hours when one of four conditions could be expected to prevail. Unfortunately, no attempt was made to take account of the different probability structures used in describing the visibility conditions in the estimation of the random utility functions from these rankings.

As Table 6-1 indicates, the empirical results from these studies are mixed. The entry fee was found to be a significant determinant of the ranking of alternatives in both studies. However, the qualitative variables for visibility conditions were not significant determinants of utility. The Great Smoky results were somewhat more definitive. They indicated that serious impairments in visibility had a negative and significant impact on the level of utility. However, at lower levels of impairment the results for some specifications of the model contradict a priori expectations.

These studies are important because they demonstrate an alternative approach for soliciting individuals' preferences and organizing them to test hypotheses. Nonetheless, they are subject to some shortcomings.

The most important problem arises with the specification and interpretation of the random utility function estimated in these analyses. As a rule, the model specifications used in Rae's analyses of the respondents' rankings include income, the suggested price for use of the area (i. e., the fee included as an attribute of each alternative that is ranked), and one or more measures of the postulated visibility conditions. It is thus clear from context, though never explicit in the studies, that the functions are to be interpreted as indirect utility functions. As a rule, an indirect utility function would include the prices of all the goods and services consumed by the individual, not simply the fee proposed for use of the relevant recreation site. Since these prices have been omitted from the models, it must be concluded that an implicit assumption consistent with one of the appropriate forms of aggregation has been made. There are two possibilities--that all remaining goods can be treated as a Hicksian composite commodity (see Deaton and Muellbauer [1980] pp. 120-122 for discussion) or that the utility function exhibits homothetic separability in two groups of commodities. The first group of commodities consists of the services of the site under evaluation and the second includes all other goods and services.

Table 6-1. Summary of Rae/CRA Contingent Ranking Studies

Study	Sample size	Description of environmental amenity	Character of fee	Recreational quality	Number of alter-natives	Area specific alter-natives	Design choice	Empirical findings[a]	Benefit estimates[b] (1981 dollars)
Mesa Verde	205	Visibility conditions: intense plume intense haze moderate haze clear	Entry fee per vehicle, $2 to $20 (existing fee, $2)	Congestion as measured by waiting time at landmark on site	13	8	22 possible combinations of alternatives; 1 of 10 sets of 8 cards randomly given to survey respondents; combinations of alternatives always include current conditions; no clearly dominant alternative included in combinations	Entry fee, negative and significant; qualitative variables for poor visibility, negative and insig-nificant; absence of congestion, positive and significant	Intense haze to clear, $0.73 to $0.79 intense plume to clear, $1.03 to $1.13
Great Smoky	213	Visibility conditions: intense haze moderate haze slight haze clear	Entry fee per vehicle, $0 to $30 (existing fee, $0)	Availability of full program of visitor center	14	8	29 possible combina- of alternatives; 1 of 10 sets of 8 cards randomly given to survey respondents; alternatives always Include current conditions; no clearly dominant alternative included in combinations	Entry fee, negative and significant; qualitative vari-ables for visibil-ity provide some evidence for valu-ation of better visibility; intense haze, negative and significant; absence of program not important	Intense haze to clear, $7.39 to $11.22 intense haze to slight haze, $11.03 to $14.86

[a] These results are based on aggregate models and use conventional criteria for significance at the 5 percent level with asymptotic t-statistics.

[b] Based on the aggregate model.

Under the first aggregation assumption, the prices of all goods and services (other than the site under study) are assumed to change in constant proportion, and this proportion, say k, would be the relevant argument in the indirect utility function. In this case, because of the nature of the assumed pattern of price movements, an individual's preference for one good in the set cannot be distinguished from his preference for any other. Ideally, to define and estimate an indirect utility function consistent with theory requires a sample consistent both with the assumption of proportionality in the price movements of all goods and with some variation in the proportionality constant, k. Since both of these conditions are not often realized in practice, the Hicksian composite commodity theorem is difficult to use in empirical applications. * For the Rae analyses, there is no way. either to know whether the prices of all other goods and services change in a proportional relationship across all individual respondents or to measure the magnitude of these proportionality constants. These unknowns are important because proceeding under the assumption that a Hicksian composite can be defined and then arbitrarily assuming a constant value for it across all individuals in a cross-sectional data base is equivalent to assuming that there is no change in prices across individuals. If the respondents all come from a single geographic area (i.e. , in a region immediately around the site), this assumption may be reasonable. However, based on evidence of substantial regional variation in prices, this implicit assumption is untenable for sites that draw visitors from around the nation. Moreover, to the extent the price variation is not simply by a constant multiple for all goods and services, the assumptions of the composite commodity approach to aggregation would be violated. †

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*It can be used in controlled experiments where the prices confronting an economic agent (i. e., household or firm) are selected by the analyst. For the most part it has been an analytical device used in theoretical analysis. Indeed, Deaton and Muellbauer [1980] raise comparable reservations, noting that:

> The usefulness of this theorem [i.e. , the Hicksian composite commodity theorem] in constructing commodity groupings for empirical analysis is likely to be somewhat limited. . . . in an open economy with a floating exchange rate, considerable fluctuation in relative prices can be expected and even without this, it is not clear that we could justify the types of aggregates that are usually available. (pp. 121-122).

They do, however, note that greater justification is available for use of the theorem with single period aggregation.

†The Bureau of Labor Statistics (BLS) data used to derive regional cost of living indexes provide evidence of both variation in the levels of prices by region and differential patterns of change among these prices for different goods and services.

The second approach to structuring an indirect utility function so that it approximates the models. in Rae's analyses would involve assuming that the direct utility function exhibits weak separability. That is, a given general utility function $U(X_1, X_2, . . ., X_n)$, with X_i the ith vector of goods and services can be written as $U(U_1(X_1), U_2(X_2), . . ., U_n(X_n)))$, with each of the subfunctions *$U_i(.)$) a homothetic function. This specification implies that the indirect utility function can be expressed in terms of the price (or fee) for the site's services, income, and a price index for all other goods and services. This price index can be normalized at unity for a given set of values for the Prices of all other goods and services. However, if it is assumed to be unity for all respondents, it is implicitly assumed that all respondents face the same prices (or different price sets that always lead to a unitary value for the index). As in the case of the composite commodity aggregate, the plausibility of this assumption --i.e. , holding the price index at a constant value for all individuals--depends upon whether or not respondents come from a small region surrounding the site. Otherwise, some variation can be expected, both in price and in the value of the price index.

Aside from this issue, the use of the homothetic separability assumption also restricts the nature of the income effects- for goods within each grouping--i, e., subfunction as given earlier, as $U_i(X_i)$--and the nature of the substitution effects for commodities involved in different groupings. To illustrate the nature of these constraints, consider the case of Rae's applications where the utility function is assumed to be composed of two groups of commodities -- the services of the site under study and the set of all other goods and services. It is convenient to use the framework of conditional demand functions to illustrate the demand effects of the separability assumptions. * For example, the income elasticity of demand for any commodity in the set of goods and services (other than the site) can be defined as a product of the income elasticity of demand in the conditional demand function† and the elasticity of the expenditures on this set of goods with respect to income. More formally, let q. designate the quantity demanded for the ith commodity in this set; e, the expenditures on all commodities in the set; and y, the individual income. Thus, if q_s is the use of the relevant site's services and ps is the price per unit of use,

$$e = y - p_s \cdot q_s \quad . \tag{6.8}$$

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*For a discussion of conditional demand functions, see Pollak [1969, 1971]. Summaries of his work are available in Deaton and Muellbauer [1980].

†This elasticity is the percentage change in the quantity demanded of the good with respect to a percentage change in the expenditures on all goods in the set. These expenditures play the same role in conditional demand functions as income would in a conventional demand function. In general, the determination of these expenditure levels will be a function of the level of income and the prices of all goods and services. See Blackorby, Primont, and Russell [1978] and Pollak [1971] for further discussion.

The conditional-demand function for q. will be related to the prices- of all goods in its group, P_i, and the expenditure! on this group (i. e., q_i = ‘i(pi, e)) will be responsive to” income and the prices of all goods. This association can be used to derive the following relationship between demand responses:

$$\frac{\partial q_i}{\partial y} = \frac{\partial f_i}{\partial e} \cdot \frac{\partial e}{\partial y} \quad . \tag{6.9}$$

In elasticity-terms, Equation (6.9) can be written as:

$$\frac{y}{q_i}\frac{\partial q_i}{\partial y} = \left(\frac{e}{q_i}\frac{\partial f_i}{\partial e}\right)\left(\frac{y}{e}\frac{\partial e}{\partial y}\right) \quad . \tag{6.10}$$

Homotheticity of this subfunction that reflects decisions about all other goods implies that the income elasticity in the conditional demand functions for these goods will be unity. Thus, the first term on the right side of Equation (6.10) will be one. Thus, Rae’s model implicitly maintains that all goods consumed by the individual (aside from site services) have equal income elasticities and are equal to the expenditure elasticity with respect to income.

This analysis can be extended one step further. Budget exhaustion implies that the share weighted sum of the income elasticities will be unity, as in Equation (6.11)

$$K_s \cdot \varepsilon_{sy} + \sum_{i=1}^{n} K_i \, \varepsilon_{iy} = 1 \quad , \tag{6.11}$$

where

K_s = share of income spent on the site’s services

K_i = share of income spent on the ith commodity

ε_{sy} = income elasticity of demand for a site’s services

ε_{iy} = income elasticity of demand for the ith commodity.

Using Equation (6.10) to substitute for ε_{iy} in Equation (6.11) gives

$$K_s \, \varepsilon_{Sy} + \varepsilon_{ey} \sum_{i=1}^{n} K_i = 1 \quad , \tag{6.12}$$

where

$$\varepsilon_{ey} = \frac{y}{e}\frac{\partial e}{\partial y} \quad .$$

While homothetic separability of the utility function does not in general restrict ε_{sy}, it does have implications for the cases in which it would be likely to be plausible. Rearranging the terms in Equation (6.12) gives

$$\varepsilon_{Sy} = \frac{1 - \varepsilon_{ey} \sum_{i=1}^{n} K_i}{K_s} \quad . \qquad (6.13)$$

Since the grouping implicitly required for Rae's model involves all other goods in the set designated as q_i, i=1, 2, . . ., n, it is reasonable to expect that ε_{ey} would be close to unity. That is, expenditures on the majority of the items in the individual's budget are likely to change in percentage terms as income does. This implies that the income elasticity of demand for site services will also have to be close to unity to satisfy the adding-up condition on income elasticities (i. e., Equation (6.11)). Equation (6.13) illustrates this conclusion.

Of course, this conclusion is a judgment. Indeed, the appraisal of the plausibility of using the composite commodity to explain Rae's models was also based on a judgment. What is at issue is an evaluation of the implicit assumptions of a model's specification for the properties of its results (or conclusions). The forgoing appraisal suggests that the assumptions necessary to interpret Rae's model as an indirect utility function are fairly stringent. Both sites attract visitors from substantial distances. Thus, omitting the relevant price aggregate for other goods may be an important consideration for the properties of the estimates of compensating surplus derived from Rae's indirect utility functions.

Regardless of how one judges the plausibility of the assumptions required to ignore other goods and services, there is a further issue arising from Rae's definition of the compensating variation. To illustrate the problem, consider an example. Assume that Equation (6. 14) defines the deterministic component (V) of the random utility model, which is assumed to be a function of the individual's income (Y), the entry fee (F), and the specified level of visibility (v):

$$V = \alpha_1 Y + \alpha_2 F + \alpha_3 v \quad . \qquad (6.14)$$

Rae's proposed benefit measure is the increment to fee that must accompany a change in visibility to hold utility constant. When Rae assumes that dY = 0, this increment is given for the example by Equation (6.15):*

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*Assuming dY = 0, this is derived by totally differentiating Equation (6.14) as:

$$dV = \alpha_1 dY + \alpha_2 dF + a_3 dv \quad .$$

Holding utility constant in expected value, dV = 0, or

$$\alpha_2 dF + a_3 dv = 0 \quad .$$

Solving for dF gives:

$$dF = - \frac{\alpha_3}{\alpha_2} dv \quad .$$

$$dF = -\frac{\alpha_3 dv}{\alpha_2} \tag{6.15}$$

Equation (6. 15) is not compensating variation. This Hicksian measure of consumer surplus is defined (see page 2-4) to be the income change required to hold utility constant in the presence of a change in the quantity of a good or service, such as visibility.

Thus, the interpretation of these benefit measures depends upon the type of fee. If it is a fee per unit of use, Equation 6.15, strictly speaking, does not measure compensating variation. Of course, the extent of error depends upon the level of repeated use. If, for example, "users are expected to visit the site only once, Rae's measure should not be appreciably different from one based on the income changes. However, if there are repeat visitors, it may be a source of error in the benefit estimates. In pragmatic terms, as shown below, the use of price versus income for measuring the benefits associated with a specified change in water quality markedly affected the resu lts. Moreover, in the present study, the fee was described as an annual payment rather than a price per unit of use. *

There are several additional problems with these studies. The Rae applications fail to include respondents' characteristics in the estimated utility functions. Presumably, this approach was adopted because two models were estimated. The first was specified under the assumption of constant parameters across al I respondents (the "aggregate" form). The second permitted these parameters to be different for each individual. Thus, this second format provides the flexibility of permitting all individuals to be different in their determinants of utility. However, to estimate a model with this flexibility, a reasonably large number of ranked alternatives is required. It is not clear that this general framework is helpful to interpreting the resuits. Detailed analysis of the parameter estimates across different groups of individuals would be necessary to understand the importance of an individual's attributes in determining his preferences for water quality.

Despite these qualifications, Rae's applications have been valuable. They have identified a new approach for evaluating individuals' preferences for nonmarketed goods and services, and they have contributed to an understanding of the issues associated with using the random utility model for consistent benefit measurement.

6.5 MONONGAHELA CONTINGENT RANKING EXPERIMENT: DESIGN AND ESTIMATES

Since the Monongahela survey was designed to compare approaches for measuring the benefits of water quality improvements, one section of the ques-

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*Since Rae's approach has been followed, and since the role of the prices of other goods and services has been ignored, the problems raised earlier as judgmental issues may also have contributed to these findings.

tionnaire included questions designed to elicit contingent rankings. There are several important distinctions between the Monongahela survey's contingent ranking component and the procedures used by Rae.

For the Monongahela survey, individuals were given a smaller number of alternatives to rank: four combinations of water quality and annual payments in the form of higher taxes and prices. This number is approximately one-third that in Rae's experiments and affects the Monongahela survey's abi lity to estimate what Rae describes as "individual" models. * Equally important, while all the Monongahela survey respondents received the same four sets of alternatives, individuals in the Mesa Verde and Great Smoky experiments were randomly assigned one of ten different sets of alternatives to be ranked. sufficient. experience has not yet been acquired with the estimators of these models to judge the implications of this difference in experimental design.

A further distinction arises in the composition of each set of alternatives to be ranked. The procedure used in the Monongahela survey inciudes four sets of conditions for the Monogahela River. Table 6-2 details the combinations used, and Figure 6-1 provides an example of the cards presented to each respondent for ranking. In contrast, the Rae surveys included other sites in the set of alternatives to be ranked. Specifically, the Mesa Verde study included 5 of the 13 alternatives as other sites, and 6 of 14 alternatives in the Great Smoky study were other sites. The rationale for this practice was described as an attempt to:

> reflect the fact that alternative sites are available and to cause respondents to focus broadly on all the characteristics of a site that contribute to overall enjoyment of National Parks and outdoor recreation areas. (Rae [1981 b], p. 3-1)

Of course, to the extent that one accepts the assumption of independence of irrelevant alternatives that underlies the random utility models used in these applications, these other sites should not be important to the rankings provided by survey respondents. ?

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*The ordered logit estimator permits the estimation of different alternative-specific effects for each individual in the sample if there are sufficient alternatives ran ked. See Beggs, Cardeil and Hausman [1981] for a discussion of the identification problem in such cases.

Rae refers to a constant parameter model for ail individuals as the "aggregate" model and to the model that allows variation in the parameters describing the effects of the characteristics of alternatives across individuals as the "individual" modei.

†The procedure used in the Mesa Verde study involved asking respondents first to rank the Mesa Verde alternatives and then to place the non-Mesa Verde alternatives within the ran king. Presumably, the same procedure was used in the Great Smoky study.

Table 6-2. Combinations of Water Quality and Payment for Monongahela Contingent Ranking Survey

Alternative	Water quality level	Annual payment
1	E RFF water quality index = 0.8 No recreation possible	$5
2	D RFF water quality index = 2.5 Boating possible	$50
3	C RFF water quality index = 5.0 Boating and” fishing possible	$100
4	B RFF water quality index = 7.0 Boating, fishing, and swimming possible	$175

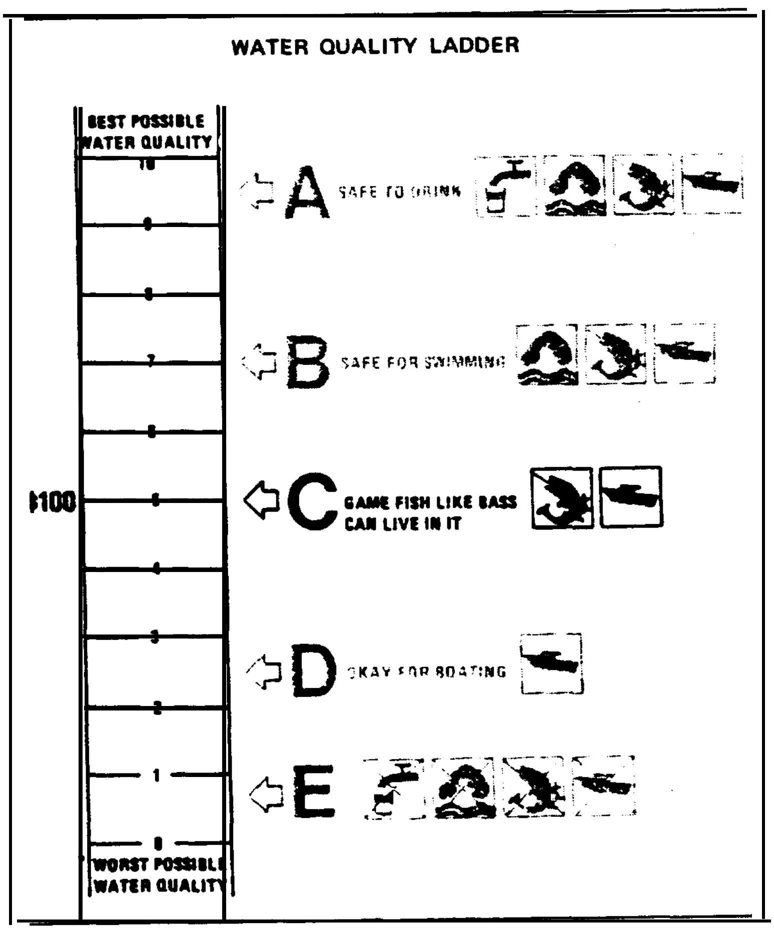

Figure 6-1. Rank order card.

Finally, the Payment vehicle included in the rankings conducted by Rae was a price per unit of use--an entry fee to the park. By contrast, the payment vehicle in the Monongahela survey was independent of the use made of the river. It is therefore an adjustment to income. This distinction affects, as we noted earlier, the interpretation of the specifications for the random utility model.

The rank order cards used to describe each alternative included the RFF water quality ladder as described earlier in Chapter 4 and repeated in Figure 6-1. All survey respondents were asked to rank the four alternatives summarized in Table 6-2. In making these judgments, interviewers were instructed to refer to the value card (see Figure 4-6 in Chapter 4) and to ask individuals to consider actual and anticipated use of the river. The specific question used was:

> First, I would like you to rank the combinations of water quality levels and amounts you might be willing to pay to obtain those levels in order from the card, or combination, that you most prefer to the one you least prefer. I would like you to do this based only on your use and possible use in the future of the Monongahela River. That is, keeping in mind <u>only</u> Parts I and II of the value card.

Two hundred thirteen of the 301 survey respondents provided usable rankings and family income information. Thus, they provide the basis for the empirical analysis. We have followed Rae's implicit assumptions and interpreted our model as an approximation to an underlying indirect utility function. However, given the incomplete information on an individual's other consumption choices, we have not attempted to include the prices of other goods or to impose restrictions on the nature of the function estimated. A variety of specifications for the model were considered under this general format and the "best" selected based on the ability of the model to "fit" the data and agreement of the signs of the estimated parameters to a <u>priori</u> expectations. The final section of this chapter discusses the implications of extending the model to consider the role of other prices in the indirect utility function.

As noted earlier in this chapter, two estimators have been developed for random utility functions. One of them, an ordered logit estimator, was used in Rae's analysis of the Mesa Verde and Great Smoky contingent ranking results , Because it exhibited rapid convergence and performed reasonably well in unpublished Monte Carlo experiments performed by V. K. Smith and D. Waldman to evaluate the estimators, the logit has been used to screen alternative specifications for the random utility model. * The second estimator

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*To evaluate the relative performance of the ordered logit and ordered normal models, Smith and Waldman [1982] conducted a limited number of sampling studies. In general, each estimator performed best with the experiments using the estimator's assumed error (i .e. , Weibull for ordered logit, normal for ordered normal). However, the ordered normal was close to comparable to the ordered logit with the Weibull distribution.

based on a normal specification for the errors in the utility function has much greater computational costs and was therefore applied to only the “final” model specifications for comparative purposes. *

Table 6-3 reports a selected set of results for the random utility model with the ordered logit model. Variables describing the alternatives ranked and the features of the individual respondent were included in the model. The models are distinguished according to the variable used to interact with features of respondents (payments or water quality); the specified form of the relationship between family income and payment in the model; and the attributes of respondents included in the model. Water quality was measured using the RFF index scale as it appeared on the rank order cards presented to survey respondents. The income measure is family income in thousands of dollars. Age (in years), education (in years), race (1 = white), and sex (1 = male) qualitative variables were also considered. Three additional qualitative variables were also included in some of these models: boat ownership (Boat own = 1 for owners); participation in any outdoor recreation in the past year (participate = 1 if yes); and the individual’s attitude toward paying for the costs of controlling water pollution (attitude = 1 if individual considers himself very or somewhat willing).

This study’s results provided stronger support for the methodology than Rae’s findings. Both the payment and water quality measure are statistically significant and correctly signed in most of the model specifications. The experimental design induced a high correlation between payment and water quality (simple correlation = 0.99), and this may explain the results for specification (2) in the table. Each equation in the table has three columns to identify whether it is an individual-specific variable entered individually in the model (the first column) or a respondent-specific variable entered in interaction form with either the payment (the second column) or water quality (the third column). Respondent-specific variables must be entered in interaction form because the rankings are modeled as a function of the differences between the values of the deterministic portion of the random utility function for each of the alternatives being ranked. Consider a simple example. Let V_{ij} designate the utility individual i derives from alternative j. Individual i will rank alternative j superior to alternative k if $V_{ij} > V_{ik}$. Thus, the probability that alternative j is ranked ahead of k will be equal to the probability that $V_{ij} > V_{ik}$. If it is assumed that the deterministic component of V is a linear function of one individual characteristic (Z_{1i}) and one variable describing the alternative (Z_{2j}), V_{ij} can be rewritten as:

$$V_{ij} = a_0 + a_1 Z_{1i} + a_2 Z_{2j} + \varepsilon_{ij} \qquad (6.16)$$

Using the same relationship to describe V_{ik} gives the following expression for $V_{ij} - V_{ik}$:

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*Comparability between the results of logit and probit models for bivariate dichotomous problems, as found in Hausman and Wise [1978], do not necessarily apply. The two error assumptions will yield approaches that are equally comparable with ranked data.

Table 6-3. Selected Results for the Random Utility Model with Ranked Logit Estimator[a]

	Model and ● ltm'native-specific interaction											
	(1)			(2)			(3)			(4)		
		Interaction with individual-specific variables[b]			Interaction with individual-specific variables[b]			Interaction with individual-specific variables[b]			Interaction with individual-specific variables[b]	
Independent variables	Alternative specific	P	WQ	Alternative specific	P	WQ	Alternative specific	P	WQ	Alternative specific	P	WQ
Alternative specific												
Payment (P)				-0.044 (-0.236)			-0.046 (-8.922)			-0.067 (-3.957)		
Water quality (WQ)	-0.151 (-1.437)			0.030 (3.025)			1.364 (8.931)			1.919 (4.121)		
P x WQ				-0.006 (-9.342)								
Individual specific[c]												
Income (x)		-0.10×10^{-3} (-1.760)				0.42×10^{-5} (-0.002)			0.15×10^{-4} (0.800)		0.25×10^{3} (0.581)	-0.43×10^{-2} (-0.370)
Income (+)												
Participate (x)			0.150 (3.384)									
Boat own (x)						-0.055 (-0.967)			0.005 (0.949)		-0.137 (-0.942)	0.402 (1.022)
Age (x)			-0.002 (-1.280)						-0.004 (-3.342)		0.0004 (1.435)	-0.015 (-1.846)
Sex (x)			0.077 (1.911)						0.075 (1.732)			
Education (x)			0.016 (2.762)			0.017 (2.530)						
Race (x)			-0.015 (-0.247)									
Attitude (x)						0.380 (7.455)						
Log (L)		-656.25			-550.69			-628.03			-628.28	

● The numbers In parentheses below the estimated parameters are the asymptotic t-ratios for the null hypothesis of no association; n = 213. (continued)

[b]The columns (i. e., P or WQ) Indicate which interaction is used in each modal specification,

[c]The multiplication signs (x) indicate that the individual-specific variable is entered in multiplicative interaction with either the payment or water quality. The division sign (+) indicates that income is ● ntered in as a division.

Table 6-3. (continued)

Independent variables	(5) Alternative ● pociflc	(5) Interaction with individual - specific variables[b] P	(5) WQ	(6) Alternative specific	(6) Interaction wlth individual - specific variables[b] P	(6) WQ	(7) Alternative specific	(7) Interaction wlth individual - specific variables[b] P	(7) WQ	(8) Alternative specific	(8) Interaction wlth individual - specific variables[b] P	(8) WQ
Alternative specific												
Payment (P)	-0. 0s2 (-9.769)			-0.053 (-6.215)			-0.046 (-6.101)			-0.043 (-7.764)		
Watar quality (WQ)	1.300 (9.113)			0.999 (6.572)			0.959 (6.520)			0.706 (5.230)		
p x WQ												
Individual specific[c]												
Income (x)		-0.20×10^{-5} (0.035)										
Income (+)					-0.280 (-7.000)			-0.273 (-6.926)			-0.280 (-7.000)	
Participate (x)												
Boat own (x)		-0.002 (-0.677)			-0.003 (-1.700)							-0.094 (-1.709)
Age (x)												
Sex (x)								-0.0001 (-0.066)				
Education (x)		0.0006 (2.476)			0.0004 (2.000)			0.0006 (3.374)				0.010 (1.667)
Race (x)												
Attitude (x)		0.012 (7.316)			0.013 (6.944)							0.351 (7.468)
Log (L)	-MM. 19			-571.69			-598.44			-567.99		

The title row above the model columns reads: Model and ● lternative-spaclflc interaction.

[a]The numbers in parentheses below the estimatad parameters are the ● symptotic t-ratios for the null hypothesis of no association; n = 213.

[b]The columns(1 ● ., ● or wQ) indicate which interaction is used in each model specification.

[c]The multiplication ● loos (x) indicate that the individual-specific variable is entered in multiplicative interaction with either the payment or water quality. The division sign (+) indicates that income is entered in as a division.

$$V_{ij} - V_{ik} = (a_o + a_1 Z_{1i} + a_2 Z_{2j} + \varepsilon_{ij}) - (a_o + a_1 Z_{1i} + a_2 Z_{2k} + \varepsilon_{ik}) \quad (6.17)$$

simplified, this expression is:

$$V_{ij} - V_{ik} = a_2(Z_{2j} - Z_{2k}) + \varepsilon_{ij} - \varepsilon_{ik} . \quad (6.18)$$

Thus, the variables describing each individual are not involved in describing how that individual ranks alternatives since they will remain constant for all alternatives. *

One of the most puzzling aspects of the results is the effect of the income variable. Because the payment vehicle was constant regardless of the level of use, the multiplicative interactions between income and the payment or between income and water quality would have been expected to provide better results than income divided by payment. However, the results indicate that the income divided by payment form is a significant determinant of the utility function implied by the rankings, while the other forms are not. In all cases, the signs for the estimated parameters are difficult to interpret. A priori expectations would have suggested that income relative to payment be a positive determinant of utility and not negative.

Of the remaining determinants considered, only education and the attitude toward paying for the costs of controlling water pollution were consistently significant determinants of utility. Both variables' parameters are consistent with a priori expectations. Based on the value of the log-likelihood function at the maximum (LOG IL]) and the significance and consistency of the estimated parameters, Specification (8) was selected as the final model. It was reestimated with the Keener-Waldman [1981] ordered normal maximum likelihood estimator. Table 6-4 reports these results along with estimates for Model (7) for comparison purposes and repeats the ordered logit estimates for convenience in comparing the two estimators with each of these specifications.

The two estimators yield quite similar results. The signs and significance of estimated parameters are comparable for the final model and for Specification (7). In general, the Keener -Waldman [1981] estimated parameters are smaller in absolute magnitude "than the ordered logit. There are no specific implications of this difference, because both estimators involve scaled coefficients and the estimated parameters do not correspond to the marginal effects of individual variables on the level of utility. These difficulties in evaluating the effects of the estimator on the conclusions drawn from these methods suggest that the Rae measure of the benefits associated with a water quality improvement should be calculated with each of the estimator results for the final model (i.e. , Specification [8]). These results will be considered in the next section of this chapter.

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*See Beggs, Cardell, and Hausman [1981] for further discussion of the limitations in specifying models based on ordered data.

Table 6-4. Comparison of Ordered Logit and Keener-Waldman Ordered Normal ML Estimator[a]

Independent variable	(7)[b]		(8)[c]	
	Ordered logit	Keener-Waldman	Ordered logit	Keener-Waldman
Alternative specific				
Payment (P)	-0.048 (-8.101)	-0,039 (-7.073)	-0.043 (-7.764)	-0.033 (-7.196)
Water quality	0.959 (6.520)	0.760 (5.630)	0.706 (5.230)	0.510 (3.400)
Individual specific				
Income/p	-0.273 (-6.926)	-0.070 (-5.667)	-0.280 (-7.000)	-0.170 (-4.250)
Boat own	--	--	-0.094 (-1 .709)	-0.039 (-0.796)
Education	0.0006 (3.374)	0.0006 (3.000)	0.010 (1 .667)	0.010 (2.000)
Sex	-0.0001 (-0.066)	0.0009 (0.643)	--	
Attitude	--	--	0.351 (7.468)	0.330 (8.462)
Log (L)	-598.44	-619.46	-567.99	-582.34

[a]The numbers in parentheses below the estimated coefficients are asymptotic t-ratios for the null hypothesis of no association.

[b]This specification involves payment interaction with the individual-specific variables.

[c]This specification involves water quality interaction with the individual-specific variables.

6.6 BENEFIT ESTIMATES WITH CONTINGENT RANKING MODELS

Using ranked data, both estimators for the random utility model provide scaled values of the parameters As a consequence, the estimates do not permit direct evaluation of the utility change associated with a change in water quality. It is nonetheless possible, given that the function is interpreted as an indirect utility function to define the compensating surplus associated with changes in water quality. Compensating surplus would correspond to the changes in income that just off sets the increment to utility associated with the water quality change. Thus, it could be derived by taking the total differential of the estimated random utility function with respect to income and water quality and by solving for the income change that would be equivalent (in its effects on utility) to any water quality change. This approach is directly analogous to the definition of compensating surplus in terms of the expenditure function.* Thus, in principle, the model can be used to derive a theoretically consistent benefit measure for changes in environmental amenities. However, as noted earlier, this procedure implicitly assumes that the indirect utility function is theoretically well behaved. †

Rae's Procedure defines benefits as the change in entry fee that would offset a change in the environmental amenity (see Equation [6.15). The benefit measure for the Monongahela survey was also defined in terms of a total differential, measuring the change in payment that will offset a water quality change. As we noted earlier, since the payment vehicle is not a fee per unit of use but an adjustment to income, regardless of the individual's use of the river, the measure of compensating surplus should be invariant to the use of income or of the payment in the total differential equation. If the indirect utility function is theoretically consistent, the two measures should be equal and opposite in sign.

Of course, it should be acknowledged that the Monongahela application has maintained Rae's basic model and therefore implicitly assumes that ail other goods and services are either part of a Hicksian composite commodity or included in a separable homothetic subfunction. To the extent neither of these assumptions provides a plausible basis for treating other goods' and services' prices, estimates of compensating surplus will likely be affected. One area seems to be an especially clear example of the limitations of this assumption. The Monongahela respondents may well have used other water-based sites in the region. These sites provide services that substitute for what is

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*See Hause [1975]; Freeman [1979a]; and Just, Hueth, and Schmitz [1982] for further details.

†The properties of an indirect utility function (IDF) include:

- IDF is continuous in prices and income,
- IDF is nonincreasing in prices and nondecreasing in income,
- IDF is quasi-convex in prices, and
- IDF is homogeneous of degree zero in prices and income.

See Varian [1978], pp. 89-92.

proposed for the Monongahela sites under the various hypothetical water quality scenarios. It must be expected that they will have a different substitution influence than the remaining goods and services consumed by these individuals. This would suggest that, at a minimum, measures of the "prices" (i. e., travel and time costs) of trips to these sites should be included in the specification of the indirect utility functions for recreationists in the sample.* In addition, it implies the need for careful consideration of the relationship between whether the individual was a user of the sites along the Monongahela and the corresponding specification of the indirect utility function. Since the models used in this study do not reflect these considerations, they should be treated as fairly crude approximations of the indirect utility functions required for benefit estimation.†

The exact nature of the estimating equation for benefits will depend upon whether the individual-specific variables enter the model as interactions with water quality or with the proposed payment. To illustrate the difference, consider two simple specifications for the random utility function. In Equation (6.19), the model includes payment (P), water quality (WQ), and an individual-specific variable (Z) using a payment interaction, whereas Equation (6.20) uses the water quality interaction. Equations (6.21) and (6.22) report the corresponding equations for measuring the payment increase equivalent to water quality improvements for each:

$$V^a = \alpha_1 P + \alpha_2 WQ + \alpha_3 P \cdot Z . \qquad (6.19)$$

$$V^b = \beta_1 P + \beta_2 WQ + \beta_3 WQ \cdot Z . \qquad (6.20)$$

$$dP = -\frac{\alpha_2 dWQ}{(\alpha_1 + \alpha_3 Z)} \quad \text{(payment interaction format).} \qquad (6.21)$$

$$dP = -\frac{(\beta_2 + \beta_3 Z) dWQ}{\beta_1} \quad \text{(water quality interaction format).} \qquad (6.22)$$

It is clear from the specifications that, in either Equations (6.21) or (6.22), the benefit estimates will vary with the individual--depending on the individual-specific variables entering the final model used to summarize the respondents' rankings. Table 6-5 reports the average and range of benefit estimates for the final specification (i. e. , with the water quality interactions) of the random utility model for using both the ordered logit and ordered normal models. Because the final specification included a term with income measured relative to the payment, the estimated benefits for specified water

*These issues are currently being considered in followup research.

†It should also be acknowledged that the benefit measures calculated with the income change were several orders of magnitude greater than the price change and had the wrong sign. These results would be expected because the estimated parameter for the income variable had an incorrect sign in all models.

Table 6-5. Benefit Estimates from Contingent Ranking Models[a]

Estimator[b]	Average	Range
I	Payment = 5	Water quality change = Boatable to fishable
Ordered logit	-1.45	-72.46 to 208.67
Ordered normal	-17.72	-136.87 to 156.83
II	Payment = 50	Water quality change = Boatable to fishable
Ordered logit	62.76	39.74 to 83.31
Ordered normal	64.30	38.54 to 85.51
III	Payment = 100	Water quality change = Boatable to fishable
Ordered logit	60.04	36.74 to 74.40
Ordered, normal	62.12	36.27 to 78.40
IV	Payment = 175	Water quality change = Boatable to fishable
Ordered logit	59.47	36.12 to 72.66
Ordered normal	61.65	35.80 to 76.96
V	Payment = 5	Water quality change = Boatable to swimmable
Ordered logit	-2.62	-130.42 to 375.61
Ordered normal	-30.91	-246.37 to 282.30
VI	Payment = 50	Water quality change = Boatable to swimmable
Ordered logit	112.97	71.53 to 149.96
Ordered norms	115.75	69.38 to 153.91
VII	Payment = 100	Water quality change = Boatable to swimmable
Ordered logit	108.06	66.12 to 133.92
Ordered norms	111.81	65.29 to 141.12
VIII	Payment = 175	Water quality change = Beatable to swimmable
Ordered logit	107.04	65.02 to 130.78
Ordered normal	110.97	64.44 to 138.53

[a]These estimates are based on the 213 observations used to estimate the random utility functions.

[b]For final model, Specification (8).

quality improvements will change with the payment level at which $\frac{dP}{dWQ}$ is evaluated. The results in Table 6-5 are presented for each of the four payment levels indicated on the rank order cards, as well as for each of two water quality changes--beatable to fishable water quality and boatable to swimmable (using the RFF index on the rank order cards). The results are clearly implausible for the lowest payment level (i.e. , P = 5). Because the water quality change represents an improvement, negative values imply that improved water quality decreases individual well-being. However, for payment levels ranging from $50 to $175, the benefit estimates are stable for each water quality change (i. e., boatable to fishable and beatable to swimmable) and are approximately the same order of magnitude as the values derived from direct questioning of survey respondents. (More details on these types of comparisons are provided in the next chapter.) These estimates should be interpreted as being comparable to an option price for each water quality change, because the question identified both use and anticipated use as the basis for the ranking solicited from survey respondents.

The benefit estimates derived from the order normal model seem slightly higher than the ordered logit and exhibit a consistently wider range. Finally, the estimates remain quite stable as the payment level increases from 50 to 175. In Appendix C, comparable benefit estimates are reported for a model using payment interactions for the individual specific variables (see Equation [7] in Table 6-3). For this case, the results are also implausible at the lowest payment level. There is a somewhat larger difference between the ordered logit and normal estimates, with the averages for logit ranging from $49.17 to $51.40 for a change in water quality from boatable to fishable (and payments from $50 to $175) versus $68.75 to $72.45 for the ordered normal. Nonetheless, these changes are rather modest overall. The estimated benefits seem quite stable across the alternative specifications of the random utility model.

6.7 IMPLICATIONS AND FURTHER RESEARCH

This chapter has described and applied the contingent ranking methodology for evaluating the benefits from changes in environmental amenities such as water quality. In the process of developing the background for this approach, the first applications of the approach by Rae were evaluated. This appraisal indicated that the empirical results yielded a relatively weak association between visibility and the individual's ranking of the alternatives describing conditions at either the Mesa Verde or Great Smoky Parks. The empirical results for the Monongahela study provide much stronger support for the method. However, analysis of the theoretical foundations of the method Rae used for benefit estimation indicated it required quite stringent assumptions to be treated as an approximation of a theoretically appropriate benefit measure. It should be acknowledged that the evaluation of Rae's approach was based on an attempt to infer the implicit assumptions for his models. The underlying behavioral model and assumptions were not explicitly described in either report. Thus, this interpretation should not be attributed to his reports.

The analysis performed here has begun the development of the behavioral underpinnings for the random utility models applied to contingent rankings of alternatives involving environmental amenities, but the process is not complete. Models estimated with samples composed of users and nonusers of the Monongahela River sites have been used. A priori expectations would suggest that nonusers may require specifications for their indirect utility functions that are different from those of users. The latter should include the prices (i .e. , travel costs) for all the relevant substitute sites and the payment as an adjustment to income. By contrast, nonusers' indirect utility functions would not include these travel cost arguments.

Extensive analysis of this alternative framework for modeling respondents' rankings of the water-quality/payment alternatives was beyond the scope of the current project. The primary intention of this analysis has been to apply and evaluate the Rae/Charles River Associates methodology for benefit estimation. The analysis considered the appropriate interpretation of their proposed benefit estimator, defined an approach to benefit estimation that more closely approximated a theoretically consistent measure, and evaluated several models with two estimators of the random utility framework.

In an attempt to gauge whether these model revisions would be important, the models used were reestimated for a subset of the respondents--those individuals who used only one of the sites on the Monongahela River (i .e. , eliminating nonusers and those who used more than one site). For this sample (a total of 49 observations), the implications of treating all sites as perfect substitutes were considered, and, therefore, only the travel cost of the particular site used was entered. The results with the ordered logit estimator for models estimated with this sample under these assumptions were rather poor and suggest that the full sample of users and a more complete specification of the model will be required to judge the potential importance of the theoretical arguments calling for different random utility models for users and nonusers.